EFFECTS OF LOW FLUENCE NEUTRON BOMBARDMENT ON MATERIAL PROPERTIES OF ALUMINUM 2024 T-3 AND ALUMINUM WIRE

by

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ABSTRACT

The purpose of this work was to explore the impact of neutron irradiation (10^{18} n/m^2 to 10^{21} n/m^2) on the aluminum alloy 2024 T-3, and several corrosion resistant treatments commonly used.

The irradiation was conducted in the Utah Nuclear Engineering Programs Reactor facility using the Fast Neutron Irradiation Facility (FNIF) with a 1 MeV equivalent beam and the Center Irradiator (CI) with average neutron energy of 0.58 MeV.

Historically, materials tests have focused on mechanical failures occurring at very high fluence. These same tests have generally been conducted for pure materials: the limited research existing for alloyed materials focuses on power plant materials such as zircaloy and steel. This body of information is mainly used to avoid catastrophic performance failures. Small research and test reactors operating at low power will subject core materials to fluence from 10^{14} n/m^2 to 10^{24} n/m^2. Aluminum alloys are very common in these systems. Materials used in research reactors, such as aluminum, have been deemed adequate due to high radiation tolerance and low mechanical failure rates. While aluminum and its alloys are a well-defined set of materials in nonradiation environments, there are very little published data for them for low fluence neutron radiation.

This work measured Al 2024's (T-3) thermal conductivity, electrical resistivity, oxide layer thickness, oxide/metal interface and corrosion resistance (using passive current density)

for Alodine, Anodize type II, Anodize type III and native oxide. These measurements were taken before and after irradiation and results were examined.

Over the course of 30 to 50 years, property changes will likely impact thermal diffusion, corrosion properties and electrical properties. Defining these changes may give future engineers the tools needed to safely justify life extensions and build inspection methods to identify pre-failure conditions.

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SECTION 1

INTRODUCTION

The purpose of this work was to provide fundamental data necessary to explore the possibility of using thermography or electromagnetic signals to assess effective damage on aluminum 2024 T-3 in a neutron radiation environment.

Aluminum is a common material in research reactors due to its high tolerance to radiation damage, short activated total half-life, and low cost. As reactor systems age, it will be necessary to have a more complete understanding of the core material properties critical for control, modeling, and proper function of the reactor systems.

Material properties are a function of many different contributing factors (temperature, anneal rate, temper, purity etc.); however, when a component is placed in a radiation environment, all other factors remaining constant, the radiation induced disorder in the atomic structure drives material property changes. By measuring the extent of the induced disorder with electromagnetic/thermal signals, the extent of several different property changes can potentially be determined without having to test each property separately. This is a valuable advantage for life extension programs.

Currently, there is insufficient basic data to make good assumptions needed to model irradiated aluminum alloys. The lack of data results in poorly supported assumptions being used to predict property changes. Those assumptions can lead to predictions of electrical resistance change in Al 2024 ranging from 0.2% up to 1000% with other properties being equally difficult to predict. Theoretically, thermal conductivity will be impacted by low fluence neutron irradiation; however, it is unclear by how much. Aluminum has been determined to have a specific dislocation resistivity of $1.1*10^{-25}$ ohm-m^3 (19), suggesting significant impacts to both electrical and thermal properties. Aluminum has been observed annealing/healing at temperatures as low as 298 K (21). The annealing is driven by the diffusion of dislocations through the crystal lattice, suggesting the impact of low fluence irradiation may be negligible, not significant. The diffusion rate of mechanically induced voids has been qualitatively observed. The diffusion was a function of temperature and the voids size, and can be modeled for neutron induced voids. The model fails to explain some observations made of radiated aluminum alloys, which will be discussed in the literature review. The lack of explanation leaves a critical gap when attempting to determine what to expect as a result of low fluence neutron bombardment.

Thermal conductivity is a critical property for any reactor due to its central role in thermal performance, core reactivity, and safety requirements for centerline fuel temperatures and cladding temperature profiles. Research examining radiated aluminum has focused mostly on mechanical failures at high fluence, creating a knowledge gap for low fluence thermal, electrical and corrosion property changes. These low fluence property changes are critical for the exploration of thermography or electromagnetic signals as potentially useful Non-Destructive Inspection (NDI) methods in research reactors.

Because aluminum is resistant to radiation damage (changes very little when subjected to high fluence), demonstrating the ability to measure damage at low fluence will create a basis for the future development of a series of NDI technologies applicable to other materials in both research reactors and power reactors. The information generated by this work will also provide future design engineers with the ability to construct hostile nuclear environment systems with a greater degree of confidence when using aluminum.

1.1 Objectives

The objective of this work was to measure the thermal conductivity and electrical resistivity of AL 2024 after it has been irradiated with neutron fluence ranging from 10^{18}-10^{21} n/m^2. These samples were prepared with a series of different corrosion resistant surfaces (Anodize type II, III, IIB and native oxide) and were assessed for corrosion rates as a function of the fluence using passive current density and weight gain. The corrosion measurements included an analysis of the oxygen diffusion through the oxide layer.

Information regarding diffusion of oxygen through the metal oxide layer, diffusion of radiation induced dislocations in the crystal, corrosion resistance, thermal conductivity and electrical resistivity will all add to the framework of existing theories. The results will clarify existing theories with respect to irradiated aluminum. This new data, in the context of existing data, will provide additional basic framework for future NDI technologies using thermal or electrical signals.

SECTION 2

LITERATURE REVIEW

The purpose of this section is to provide a general background for the research performed.

2.1 Aluminum

Nuclear engineering designs rely heavily on material properties in order to achieve performance goals. The first design consideration typically centers on neutron matter interactions. Materials with small neutron cross sections and short half lives are the most useful because the risk to personnel is reduced, waste volume and the intensity of radioactivity is reduced and ultimately disposal costs are greatly reduced. These reductions are achieved because so few neutrons interact with low cross section materials and short half-lives result in rapid reduction of the radio activity generated by neutron bombardment.

Depending on the design application, other properties, e.g., strength, toughness, heat capacity, melting point or thermal conductivity may also be critical. In reactor cores, thermal conductivity is essential for proper thermal behavior, reactor control, and core modeling. In power reactors, melting points are important because of the high temperatures maintained during steady state operations. Conversely, high melting points are not as critical for research reactors, space applications, hostile environment robots and many electronics.

Aluminum (Al) is an ideal material for use in nuclear environments because it has a very small neutron cross section (~$0.2\text{-}0.6 \times 10^{-24}$ cm^2) (*1,2*), and Al- 28, the main isotope generated from neutron bombardment of Al-27, has a short half-life of 2.2405 min (*3*). In addition to having a small cross section and short half-life, aluminum and its alloys have demonstrated high tolerance to neutron bombardment (*6, 7, 8*), with some alloys not having observed void formation until $8*10^{25}$ n/m^2 and no precipitates until $2*10^{25}$ n/m^2 (*8*). Aluminum is also a good conductor of thermal energy (*5*), making it an attractive candidate for reactor core use.

While aluminum has many of the traits desired in reactor core structures, it is not used in commercial power plants due to its low melting point, 660° C (*4*).Power plant steady state cladding temperatures, centerline fuel temperatures, and safety margins preclude the use of aluminum metal and its alloys for commercial power core applications. While the melting point precludes the use of aluminum in power reactors, it is an ideal material for research reactors where the temperatures are much lower.

Material properties of aluminum, as a function of fluence, have been a subject of study for many years. Much of this work examines the many different effects, ranging from microstructure to macrostructure, of high fluence neutron irradiation. There is, however, very little corrosion, mechanical, electrical, or thermal property data describing the effects of low fluence neutron irradiation (LFNI) on aluminum and its alloys. While existing models can be used to predict property changes at those low fluence levels, experimental data supporting conclusions at low fluence ranges is not available in large amounts.

Some research describing aluminum and its alloys subjected to LFNI has appeared in published works over the last 50 years. Work done on Aluminum 6061 (*9, 10, 11*) described low fluence irradiation on that alloy and was summed up by King (*12*), who observed Al

6061 increases slightly in strength but loses ductility as a result of irradiation. More recently, the corrosion behavior of aluminum in a brine solution subject to high gamma low neutron flux was explored (*13*). The gammas in the brine solution experiment hindered the generation of oxide forming compounds on the surface of the metal in the solution, which effectively eliminated pitting. Once the samples were removed from the high gamma flux environment, the research teamed terminated the study. With the loss of the gammas and the reintroduction of oxide forming compounds, the extent of the microstructure radiation damage providing nucleation points for pitting and accelerated corrosion was not quantified. The question was not explored in this case, nor are the data readily available in the public domain.

Thermal conductivity in LFNI aluminum has also been a subject of study. Misiorek et al. (*14*) reported the effects of neutron irradiation on the thermal conductivity of aluminum (3-N through 6-N) subjected to fluence ranging from 10^{17} to 10^{20} n/m^2. The results demonstrated conductivity changes as little as 10% and as severe as 50% depending on purity and temperature of the samples. While most of the work examining irradiated aluminum has focused on high fluence effects, and the resulting models suggest the completed loss of low fluence dislocations through diffusion, the results of Misiorek et al. suggest low fluence irradiation effects are not insignificant and may not simply disappear when the flux stops. Work on other material such as zircaloy and steel also suggest a residual retention of induced dislocations following irradiation.

The relationship between thermal conductivity and electrical resistance is based on the flow of electrons in the lattice and is described by the Wiedemann-Franz law (WF law) (*15*), which make thermal conductivity and electrical resistivity a function of one another. This means, one property, once known, can be used to determine the other (*16,17*). In this study, a single measurement of either property can be used to predict thermal conductivities from cryogenic to room temperatures for pure aluminum and aluminum alloys (*16, 17, 22*). Using the processes outlined in the literature (*16, 17, 22*) and the data provided by Misiorek et al. (*14*), calculations can be made suggesting the thermal and electrical conductivity changes in aluminum subjected to LFNI at room temperature will be significant, which impact thermal hydraulic and temperature mapping reactor core models used to quantify research reactors. This calculation raises the potential that electrical resistivity measurements can be used to assess the effective dose and its impact on aluminum fuel cladding and other core components.

When a neutron hits the nucleus of an atom in the aluminum lattice, the struck atom is dislocated and a damage cascade ensues. Each dislocation will result in resistance to the flow of electrons, which will affect the thermal resistivity. Single dislocations have been studied to the point which specific dislocation resistivity in aluminum has been theoretically derived ($1.3*10^{-25}$ ohm-m^3) (*18*) and experimentally ($1.1\pm.4*10^{-25}$ ohm-m^3) verified (*19*). Historically theses values have been considered temperature independent.

Kaveh noted values reported in the literature, up to that point, for the specific dislocation resistivity in aluminum ranged from $0.7\text{-}7*10^{-25}$ohm-m^3 and argued for a temperature dependent and dislocation density dependent relationship, but did not make a case for changing dislocation equilibrium values based on the thermodynamic properties of aluminum (*20*). By calculating the number of neutron collisions with the aluminum cladding in a research reactor operating at 90 kW, the number of dislocations can easily be determined. Using the specific dislocation resistivity with the assumption that dislocation density, temperature and annealing are insignificant, the number of dislocations generated combined with the Wiedemann-Franz law predict a new thermal conductivity for the cladding. The exercise shows aluminum will cease to be a thermal conductor and become a thermal insulator. However, this is not the case observed over time in research reactor cores. Temperature dependence and dislocation density dependence combined with diffusion of dislocations may adequately explain why extreme property swings are not observed after irradiation. While dislocation generation rate, diffusion of dislocations, and dislocation annihilation have all been studied, aluminums thermal property behavior following neutron bombardment has not been assembled into one unified model nor have measurement been made to verify predicted property changes.

Dislocation resistivity was addressed again in 2000 by Schafler et al. (*21*). In this study, mechanical voids of different size were introduced into the aluminum being tested. Observations were made for temperature dependence, void size dependence, and annealing from cryogenic ranges to room temperature. The authors compiled the data to described temperature dependence for dislocation resistivity. The most interesting trends showed the smallest voids required higher temperatures and more time to anneal while large voids required the least time and lower temperatures to anneal. The data showed void size dependent annealing rates and different asymptotic limits with the smallest voids annealing the least. Schafler et al. also reported high dislocation densities led to higher rates of dislocation annihilation. The effects of void concentration and void size on anneal rates were noted in the work, but diffusion coefficients, were not quantified or modeled. While the research did not address diffusion coefficients the results suggest the coefficients, in addition to temperature, are a function of void size and concentration, which is consistent with void recovery kinetics.

2.2 Comparable Studies of Similar Metals

Recent research appears to be focused on materials widely used in commercial power plants today. Critical industrial infrastructure life extension and component replacement programs rely heavily on a better understanding of these materials and their properties during and after irradiation. Zircaloy is one material heavily utilized for fuel cladding because it has many of the same desirable traits as aluminum with one critical exception: a much higher melting point.

Similarities between aluminum and zircaloy with respect to nuclear, mechanical and corrosion properties qualitatively suggest the two may have similar responses to irradiation. The data available for zircaloy, while still being explored, are far more complete than it is for aluminum. This requires an educated assessment of possible experimental results due to limited direct research for LFNI of aluminum. It is therefore necessary to produce assumptions for Al based on the studies that have been conducted for similar materials.

Reported data for irradiated zircaloy have demonstrated some interesting results. High fluence neutron irradiation of zirconium has results in its transition from a crystalline structure to an amorphous structure (*28*); the case has also been made for the enhancement of cracking of the oxide film under irradiation (*23*). The corrosion resistance of Zircaloy subjected to heavy ion irradiation also has been successfully measured using passive current density (*23, 25*), which shows significantly altered behavior based on fluence.

Neutron and heavy particle irradiation both cause displacements in the crystal structure but are difficult to compare directly. Neutrons are not heavy ions and have a much smaller collision probability and less kinetic energy imparted during a collision, which means more fluence is necessary to observe the same level of damage. Lighter particles also cause a more uniform damage profile than heavy ones, giving rise to additional difficulty in conducting a direct comparison. These factors demonstrate why it is necessary to conduct laboratory experiments in a research reactor to acquire reliable data.

The corrosion mechanism for aluminum and zirconium is very similar, and primarily driven by an equilibrium struck between the diffusion of oxygen into the metal and the thickness of the metal oxide (M/O) layer. The impact of neutron irradiation on the M/O layer is critical to understand corrosion effects of irradiation. Corrosion kinetic and M/O layer stability have been examined using a tunneling electron microscope (TEM) (*26*) and X-ray diffractometry (XRD) (*24*). The TEM study demonstrated significant impacts resulting from neutron irradiation subjected to a fluence of 10^{26} n/m^2 and higher. While the TEM study focused on the oxygen profiles at the metal-M/O interface and the radiation affected diffusion coefficients, the XRD study focused on the stresses formed in the oxide layer resulting from different treatments and how that affected corrosion in lithiated water and 400°C steam. The XRD study demonstrated the impact that deliberate anti-corrosion engineered M/O layers can have on the susceptibility to oxidation.

A variety of different techniques have been developed to enhance aluminum's anti-corrosion oxide layer, some of which may be more resistant to corrosion following irradiation and thermal cycling than others. During radiation the diffusion coefficient of oxygen through the boundary may increase by orders of magnitude and oxygen will likely be readily available as the water molecules are broken down by the radiation.

Reactor water's conductivity and pH are closely monitored and controlled, which limits the corrosion process outside of the anticorrosion barrier, making corrosion a less pressing issue in research reactors. However, even in a highly controlled environment corrosion over time will likely play a key role in the systems performance.

Alumina (aluminum oxide) is an electrical insulator whose electrical properties degrade when subjected to a radiation environment, this is known as RIED (radiation induced electrical degradation). Postirradiation degradation results from structural damage; however, when the material reaches 0.1 displacement per atom (dpa) the degradation, in situ and post irradiation, stops, and the material improves as an electrical insulator (*30*). At fluencies of ~10^{27} n/m^2 alumina has had up to a 97% reduction in thermal diffusivity and ~2% swelling (*31*). Due to the properties observed in alumina, the material has potential to serve in fusion reactors and has been explored for use in the International Thermonuclear Experimental Reactor (ITER) (*32*).

When considering research reactors, the low 0.1 dpa saturation point for alumina suggests the oxide layer would experience the most electrical change without the benefits associated with the saturation point. For original design criteria the anticorrosion properties were considered critical to fuel cladding structural function, the electrical or thermal insulation properties were not. The thermal properties have also been largely ignored because the oxide layer is thin compared to the cladding and has been deemed to have negligible impact.

Earlier works examining alumina may provide additional insight for the low fluence conditions. Pells (*29*) provided a review article for alumina in 1994, which examines displacement threshold energies, particle irradiation effects, displacement damage calculations, displacement energy efficiency, evolution of damage to the microstructure, dimensional stability, thermal conductivity, electrical conductivity in a radiation environment, radiation effects on mechanical properties, and dielectric properties. This review provides a useful tool for assessing the oxide layers on aluminum prior to and after irradiation.

Unfortunately, corrosion and oxygen diffusion properties were not in the review and have proven elusive in the literature.

While a great body of information defining radiation effects in commercial materials exists, low fluence irradiation data for aluminum is sparse. Corrosion data for zircaloy may provide hints of what to expect in aluminum, but irradiated corrosion properties for aluminum are still unknown. The same is true for electrical and thermal properties. While existing work on aluminum may provide an indication of what to expect, the information is assumed and untested.

SECTION 3

CORE SECTIONS

3.1 The Material Model

Calculations were performed using MCNP5, an Oak Ridge National Lab product used widely for neutron transport and criticality calculations. These calculations provided predictions for how the neutrons in the environment would interact with the sample material. MCNP5 was also used to model energy profiles for the experimental facilities. MCNP5 tracks the path of a single neutron from the source through the system by applying probabilities of collision and mean free path, probable angles of deflection, energy deposition, primary and secondary gamma production, along with a variety of other physical properties. Statistical methods are then used in the program to determine the quality of the "answer." Depending on the size and complexity of the system being modeled the number of modeled neutrons required to obtain a good answer will vary. Shultis and Faw have developed a primer (*39*) with recommendations for settings and statistically sound results. The results generated using MCNP5 were within the recommended tolerances suggested in the primer.

MCNP5 has detailed cross section data for aluminum along with the other components of the Al 2024 alloy. Energy deposition was calculated with MCNP5 and is described in as Ed in the equation 1 below, where N is the number of target atoms, sigma (σ) is the cross section as a function of energy and energy transfer and Φ is the flux as a function of energy. E_h is the maximum amount of energy of an incoming particle and $E_l$is the minimum energy of an incoming particle and T_h is the maximum amount of energy transferred to the lattice as a result of a collision and T_l is the minimum amount of energy transferred to the lattice as a result of a collision.

$$Ed = N \int_{E_l}^{E_h} \int_{T_l}^{T_h} \emptyset(E_i)\sigma(E_i, T)\, dTdE_i \tag{1}$$

Unfortunately, MCNP5 will not model the damage cascade resulting from a neutron collision. The program works by tracking a single neutron through the system, resetting and doing it again and again until a significant statistical result is obtained to describe the system. The model is very useful to obtain a detailed description of collision frequency and energy deposition but not for damage cascades.

The damage cascade resulting from a single neutron collision will be modeled using classical physics and the experimentally reported dislocation energy for aluminum in existing literature shown in EQ 2. The symbol v is the number of dislocated atoms per primary knock on and is a function of energy transfer.

$$Ko = N \int_{E_l}^{E_h} \int_{T_l}^{T_h} \emptyset(E_i)\sigma(E_i, T)v(T)\, dTdE_i \tag{2}$$

The resulting number is the atom displacement rate and will be used to predict the number of dislocations introduced into a sample of irradiated aluminum. This number is a key data point for the remaining work. It will be the starting point for all material property change predictions. Once the experimental results are complete, it will be used to quantify the changes as a function of damage.

The damage cascade dislocations will begin radiation enhanced diffusion and annihilation as interstitials and vacancies recombine or deposit in sinks such as grain boundaries. The dislocation concentrations will be modeled using reaction kinetics shown in EQ 3 and 4.

Vacancy concentration

$$\frac{dC_v}{dt} = K_o - K_{iv}C_iC_v - K_{vs}C_vC_s \quad (3)$$

Interstitial concentration

$$\frac{dC_i}{dt} = K_o - K_{iv}C_iC_v - K_{is}C_iC_s \quad (4)$$

where K_{iv} is the rate constant for loss of interstitials to vacancies, K_{vs} is the constant for vacancies to sinks, K_{is} is the constant for interstitials to sinks, C_s is the concentration of sinks, C_i is the concentration of interstitials, C_v is the concentration of vacancies, and *Ko* is the generation rate for dislocations.

Follow on reactions and effects will be discussed in greater detail in the discussion of results for the thermal and electrical measurements.

The property changes of interest will be described in the context of equation below where the *G* function is the property change function and will incorporate energy transfer, damage cascade and diffusion. Where *T* is energy transferred to the lattice, *E* is the energy of the incoming particle and t is time.

$$\Delta P_{i,j} = \iiint G_i(E,T)\emptyset_j(E,t)dEdtdT \quad (5)$$

Property changes of primary interest are electrical resistivity and thermal conductivity. Values of thermal conductivity and electrical resistivity will be measured and then compared to initial measurements and literary data. The resulting comparisons will provide a baseline for the legitimacy and accuracy of the measurement methods developed for this experiment.

Electrical resistance and thermal conductivity are described as a function of one another using the WF law. The WF relationship was originally established for pure metals. Generally as a metal becomes diluted the WF law becomes less accurate, however in this case the WF law may still be used for an aluminum alloy to accomplish the proposed work based on established research (*17, 19, 22*).

Knowing the specific dislocation resistivity in aluminum is key to building a good model and has been derived, tested and reported to be ~$1*10^{-25}$ ohm-m^3. There are a variety of factors that possibly impact the specific dislocation resistivity. Temperature effects studied by Schafler et al. (*21*) impacted the SDR in some cases by factors as much as 20. The same work reported annealing effects at room temperature nearly eliminating dislocation impacts in less than 100 hours. Defect size and density and type also had large impacts on the resistivity of a damaged sample. The work of Schafler et al., while providing quality data, did not provide a good diffusion analysis to describe the observations in the context of diffusion mechanisms and coefficients.

By first approximation, the point dislocations introduced from neutron bombardment in pure Al will annihilate back to dislocation equilibrium concentrations without being retained. Schafler's and other's works seem to indicate a new equilibrium will be reached following doses received at levels well below 10^{23}n/m^2. This is certainly a function of overcoming the energy threshold of more permanent defects such as voids. Based on some initial samples irradiated and measured in preparation for this proposed work, Al 2024 will not experience a complete elimination of dislocations as a result of diffusion. The size of individual dislocations is expected to be very small (within 5% of the critical size for the formation of a stable void) and fairly homogenous due to the ability of aluminum to resist voids loops and other defects at the dose levels proposed for this work.

The homogenous nature of the dislocation profile and size will simplify the calculation, and allow the use of the specific dislocation resistively (SDR) of $1.1x10^{-25}$ohm-m^3. This method was used to model Al 2024 and the Al wire for alloy comparisons. The aluminum oxide layers coating the panel samples were not modeled using a SDR.

The radiation environment was expected to enhance the movement of oxygen through the oxide boundary on the panels which will thicken the oxide layer. The resulting data was described using Fick's one dimensional description of diffusion because the panels were flat and had an epoxy protective coating on the edges creating a single directional flow for the movement of the oxygen into the metal base.

3.1.1 Sample Set

The purpose of this section is to describe the samples, the alloy and the treatments. Aluminum 2024 T-3 was chosen for this work for a variety of reasons. It is commercially available, inexpensive, and commonly used. Aluminum is a material used in research reactors all over the world because it is very durable in a radiation environment, it experiences very little activation and the resulting total half-life is very short. The TRIGA reactor has aluminum 6061 clad fuel elements and an aluminum structural core. The Aluminum alloys used in this work was not Al 6061 due to ease of 2024 sample acquisition and availability of aluminum wire. As the purpose of the experiment was to generate material data for potential development of NDI technologies by identify changes in material property, the use of any alloy was deemed acceptable.

Aluminum has a low melt point so it is not used in commercial reactors and has not received the attention many commercially used materials have. Several choices came up for more commercially useful materials; however, some of these materials were prohibitively expensive or would result in the long term storage of radio-active waste samples at the University of Utah and higher expense for eventual disposal.

Considering the purpose (proof of concept), usefulness for research reactors, potential for correlation, project costs and environmental impacts, aluminum was chosen as the best candidate. Due to aluminum's robust properties in a radiation environment and its high thermal and electrical conductivity, results obtained using aluminum will demonstrate the viability of using thermal and electromagnetic signals as a basis for NDI in other metallic materials and provide supporting data for follow on studies for diffusion and alloying effects in a radiation environment.

The aluminum alloy 2024 T-3 is composed of the following material composition by percent weight: Chromium: 0.1% max; Copper: 3.8-4.9%; Iron: 0.5% max; Magnesium: 1.2-1.8%; Manganese: 0.3-0.9%; Silicon: 0.5% max; Zinc: 0.25% max; Remainder Each: 0.05% max; and Remainder Total: 0.15% max. Aluminum makes up the balance of the composition (*41*, *42*, *43*, *44*, *45*).

Neutron activation analysis (NAA) was used to measure the components in the sample and verify the sample matched the commercial description of the alloy presented above. The treatments were comprised of an Alodine, Anodize Type II, Anodize Type III, and natural oxide. The Alodine was an Irridite 14-2 class I, Type IA per Mil-Spec C5541 Type II sulfuric conversion coat, the Type III was a class I, Type III per Mil-Spec A8625 sulfuric acid anodize with a sodium dichromate sealer, the Type II was a class I, Type II per Mil-Spec A8625 sulfuric acid anodize with a sodium dichromate sealer, and the native oxide was an untreated sample. The Irridite conversion coat will be referred to generically in this report as Alodine with the native oxide referred to as either native oxide or natural oxide and the Type II and III will be referred to as Type II and Type III. Only the natural oxide was used in the NAA. The analysis indicated the presence of Sodium, Copper, Iron, Manganese, Chromium, Zinc and Cadmium. Cadmium by far has the largest capture cross section but was present in only trace amounts and could easily be an industrial contaminate. The half-lives of the isotopes created were for Mn~300 days, for Zn~244 days, for Fe~44 days, for Na~15 hours, and for Cu~12 hours. Copper (the most abundant contaminate) has a short half-life, along with sodium, which led to a rapid activity drop. The Iron was so small in its concentration it had little effect on the overall activity other than to be detectable. The Mn and the Zn while small in concentration had longer half lives and resulted in nearly a year of sample storage before disposal was acceptable. The samples which were subjected to longer irradiation periods had corresponding higher radio activity levels and longer storage times.

Multiple thermal measurements were taken from a single sample providing a statistical basis for data reporting. The same is true for electrical resistance. Diffusion effects were measured using resistance measurements and weight gain. Corrosion measurements were destructive so no less than five samples were created for testing at each measurement point. The corrosion measurements were subject to a minimum of three and a target of five panels per fluence level and coating type in order to control cost and schedule. Three successful panels measured per fluence level, was deemed to be the minimum number allowable for acceptable data reporting.

Electrical resistance as a function of flux was measured using a very fine (diameter = .001") wire of 99% Al and 1% Si. These measurements were able to capture dislocation concentrations over time in the neutron radiation environment.

3.1.2 Mechanical Properties

3.1.2.1 Aluminum

While mechanical properties are critical to designers and life extension programs, past literature has clearly demonstrated aluminum is a very robust material in nuclear applications. Swelling, clustering, blistering, etc., occur at such high fluencies that attempting to measure them using Utah's TRIGA would be futile. Therefore mechanical properties are beyond the scope of this work and were not pursued.

3.1.2.2 Aluminum Oxide

Property changes for aluminum oxide have been explored as a result of interest from the fusion research community. The mechanical, dielectric, thermal and electrical conductivities and dimensional stability properties were reviewed and compiled by Pells in 1994 (*29*). Pells reported the peak thermal conductivities of alumina were halved by as little as $3x10^{21}$ n/m^2. Detailed displacement energies and damage calculations were also reported.

Using Pells' review as a guide for understanding the alumina layer, damage calculations were completed and provide a primary explanation for some of the diffusion effects and corrosion degradations observed in this work.

3.2 Thermal Conductivity/Electrical Resistivity

3.2.1 Thermal Conductivity

3.2.1.1 Introduction

To date, voids in aluminum have not been studied at fluence levels below 10^{23}n/m^2. The work performed during this experiment, which tested Al 2024, suggests the methods presented here may be useful to examine void concentrations and retention during early void formation and build up stages in aluminum alloys.

Based on Schaflers' (*21*) observations of annealing, voids in aluminum are sensitive to temperature and size, with the larger void annealing more completely and more quickly. Schafler mechanically introduced voids and then observed the diffusion of those voids along isothermal lines (~298 K) in high purity aluminum. The bulk of diffusion occurred in the first six minutes. The smallest voids retained ~25% of the original introduced void while the large retained ~2% after 100 hours.

While not specifically addressed in Schafler's paper, it makes sense the large voids would diffuse quickly as there is more void surface area and larger lattice instabilities for larger voids, while the small voids have a much smaller void diffusion area and smaller lattice void energy foot print. It is interesting to note that after the 100 hours, the large voids (~70% of sheet thickness) reduced to 2% retention which corresponds to a ~1.4% (sheet thickness) dent in the sheet, and the small void started at 4% of sheet thickness and retained about 25% leaving it with a ~1% dent in the sheet. This result supports the critical void size concept which balances the void energy with the lattice energy.

By observing this response in the existing data we can suggest the equilibrium of small voids in pure aluminum at room temperature is ~1% (sheet thickness) following introduction. While the work is good for high purity aluminum it is well known by examining other published literature (such as those by Misiorek) (*14*) that less pure aluminum (alloys) will experience greater changes from radiation i.e. retain a substantially increased number of dislocations, while more pure aluminums will retain less dislocations.

Work done on void annealing of aluminum by Vandermeer (*38*) examined samples which were subjected to fluencies of $\sim 10^{25} n/m^2$, a range at which voids are induced in AL and swelling can be measured. The fractional recovery of the swelling was measured as a function of temperature. The percent in length was also measured at 498 K against time. Vandermeer provided a solid discussion on the theory of void volume reduction and diffusion and compared it to the data collected.

Void recovery kinetics in aluminum (explored by Vandermeer) was used as a comparison for the recovery rates of the alloys in the work presented here. This is evidence that voids are being created and recovering in a manner consistent with past work. The retention and recovery of dislocations observed as a result of low fluence radiation bombardment, demonstrate the formation of voids at these low fluence levels.

Taken together, the works by Vandermeer, Misiorek and Schafler provide a basis to move forward exploring the effects of neutron induced defects in aluminum alloys at room temperature. With cryogenic low level bombardment (5-50K and 10^{17} n/m^2) and elevated temperature high level bombardment (350 K and 10^{25} n/m^2) data available, the middle 10^{18-20}n/m^2 at room temperature data was a clear data gap. It is also the range of operation for Utah's research reactor, and provides needed information to improve defect detection, material specification, and develop potential NDI technologies that would be deployed in a nominal (293-300 K) thermal environment.

This work is meant to be a proof of concept and add information to the existing body of data where a gap is present. This work is not meant to completely fill an observed data deficiency. Experiments showing thermal conductivity effects at cryogenic temperatures with as little as 10^{13} n/m^2 demonstrate low fluence effects but leave room temperature thermal conductivity effects unknown. Concept papers for eddy current, an electrical resistance measurement method have theoretically suggested levels of 10^{20} n/m^2

can be easily measured (*33*) which lends support to the theoretical case that this work supports the potential development of future NDI technologies.

3.2.1.2 Methods

In known systems, like the University of Utah TRIGA reactor, changes in the thermal and mechanical properties of the Al (found in fuel cladding and core structure) during and after operations, will impact the accuracy of reactor models used to generate safety reports and models used to perform benchmarking experiments. Understanding changes may prove useful for increasing model accuracy and developing potential inspection technology, or may prove valuable by supporting safe life extension programs for the system.

Data in the literature clearly show differences in thermal conductivities at cryogenic temperatures as a result of neutron bombardment. From 1K-30K very large thermal conductivity differences occur as a result of fluence as little as 10^{17} n/m^2. In some cases the thermal conductivity is altered by a factor of three (*14*).

Given known effects at cryogenic temperatures, and the knowledge that dislocations diffuse more rapidly and more completely at higher temperatures, property changes as a function of radiation in Al alloys at temperatures found in operating research reactors should be experimentally examined. While those properties can be theoretically determined, they have not been measured outside of this work. In order to measure the thermal conductivity as a function of fluence the following approach was devised and implemented.

Thermal conductivity was measured by attaching a k type thermal couple wire to each end of a small rectangular prism sample at room temperature and placing one side on an ice block. The system was insulated with Styrofoam on all the other surfaces. Recording the temperature at each end with respect to time provided data to calculate the thermal conductivity, see Appendix E.2 for calculations and Appendix B.2 for the data.

Thermal testing was performed on un-irradiated samples and those measurements were compared to the literature values of thermal conductivity for this alloy. Following irradiation, the thermal testing was again performed on each sample. The results of the before and after thermal conductivity values were then calculated and reported in a percent change and linked to a dislocation concentration using the specific dislocation resistivity (SDR).

Detailed procedures for the thermal conductivity tests can be found in Appendix A.3. During the cutting stages of the sample preparation, it was noted that the geometry of the sample was not a perfect rectangular prism. The model for thermal conductively is geometrically sensitivity. As a result the imperfect rectangular prism geometry had to be addressed.

Height and length were very consistent measurements on each sample used in this test, and width varied due to the cutting process. The expected result was for the "small" end against the ice to produce smaller than literature value thermal conductivities and the "large" end against the ice to produce larger than literature value thermal conductivities. In concept, the two values should straddle the true thermal conductivity (it was assumed the reported literature value equaled the true value), which was the case for this measurement method.

While this testing procedure was developed to measure thermal conductivity it was not intended to identify the exact literature value. Instead the concept of straddling the literature value described above was used to validate the method as a good measure to determine the thermal conductivity change based on irradiation.

The measurement method performed exactly as expected based on the geometric flaws. Those same flaws should have no effect on the property change as a function of fluence as the exact same sample measured prior to irradiation was measured after irradiation in the same configuration. This configuration control method eliminated the geometric biasing and the potential error it could have introduced into the results and focused the results on the percent change for pre and post irradiation.

In addition to elimination of the geometric errors there was an additional method validation conducted. The uncertainty measurement method for the thermal testing is based on an explanation provided by Taylor's uncertainty analysis text book (*34*). The method described is a well-established and commonly used practice for identifying method/test uncertainty.

Taylor described, in the standard deviation section of his book, a box of springs all of which needed to have the spring constant measured. Taking between five and ten measurements for each spring would be time consuming and unnecessary, so five to ten measurements would be taken on one spring to determine the standard deviation of the measurement. That deviation describes the uncertainty in the measurement process and each additional spring could then be measured once and assigned the deviation determined from the first spring.

This method is commonly used to identify the accuracy of an instrument being sold on the market or in the characterization of a new testing process. The techniques developed for this test were configured in a unique design and had to be characterized. While many measurements could have been taken to exactly determine uncertainty for each data point, the value added was not worth the additional radiation exposure to the experimenter, which in this case promoted the ALARA principles.

Determining the precision of the method was accomplished by making six measurements of sample 2 and then four measurements of sample 1 prior to irradiation. The uncertainty measured at 68% confident (one standard deviation (stdev)) was ~14 and 15 percent. The method was therefore determined to have an accuracy of 15% at one standard deviation using the argument that the data only represented a sample of the population i.e.

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}} \tag{6}$$

Appendix E.13.1 provides an example calculation for the error analysis. The standard deviations calculated for the thermal conductivities assume the data is part of a larger population.

Given the uncertainty of the method, only a few measurements were taken to evaluate each of the remaining test articles. Those measurements were then assigned with a 15% uncertainty. When two were taken they were averaged and the 15% standard deviation was applied to the average. Using this method the number of measurements taken for radioactive samples was reduced and the experimenters' total resulting dose was minimized.

Also, time differences between bombardment and measurement were selected to minimize experimenter dose and reflect a typical delta that would be present based on regular operation of equipment. A research reactor like the UUTR (University of Utah TRIGA Reactor) generally has a 4-7 day period between operations which supports the >4 days wait time until measurement.

Testing was originally designed to measure the retained dislocations after the sample had been allowed to diffuse the dislocations to an equilibrium level. No special precautions were taken to address the diffusion aspect, and the measurements were taken between one week and six weeks following irradiation. Data available for dislocation diffusion in Al indicate four days is sufficient to establish a baseline of retained dislocations.

While the data did not provide an exact evaluation of the diffusion properties of the alloy, it did yield information on dislocation retention and thermal conductivity. The objective to quantify dislocation retention by identification of a critical material property change key to system performance in a hostile radiation environment was met.

3.2.1.3 Results

Thermal conductivity change results are contained in Table 1. The key assumption (Vandermeer's equation applies) allowed the comparison of these three data points, and demonstrated all three samples have achieved 99.7% of the recovery they were likely to undergo given the temperature and time between irradiation and measurement.

The equation presented by Vandermeer (*38*) is an empirical description of the elimination of void fraction observed during experimentation and is:

$$f = k \ln\left(1 + \frac{t}{t_0}\right)$$

$$k \sim .08 \ @ \sim 300\ K$$

$$t_0 = 36990sec \tag{7}$$

Using this equation as an estimator, after 11 days 99.7% of voids are recovered and by 37 days 99.9% of voids are recovered. As such, assuming the metal has reached semi lasting dislocation equilibrium within 0.2% is reasonable.

The percent reduction calculations were done using the equation

$$\%\ change = \left(\frac{\left(\frac{prerad\ value - high\ post\ rad}{prerad\ value}\right) + \left(\frac{prerad\ value - low\ post\ rad}{prerad\ value}\right)}{2}\right) x100 \tag{8}$$

Table 1

Thermal Conductivity Analysis Results

	Pac 1	**Pac 2**	**Pac 3**
Time to measurement (days)	**37**	**18**	**11**
Total damage retained (dislocations/m^2)	**1.49x10^{17}**	**1.43 x10^{17}**	**1.29 x10^{17}**
% reduction thermal conductivity	**28**	**27**	**22**
Average dislocation retention(dislocations/m^2)	**1.37 x10^{17}**		
uncertainty 1 stdev dislocation retention	**1.66 x10^{16}**	~ 12 %	

where Pac 1 and 2 had both geometries (high and low) measured for thermal conductivity that were analyzed. Pac 3 had only the small end against the ice tested resulting in only the "low post radiation" data being collected and analyzed.

The resistivity was calculated using the WF law $k\sigma = LT$ where L=Lorenz number, T=temp, k=thermal conductivity and sigma=electrical resistivity. Because the electrical and thermal conductivities are linearly dependent there is a one to one percent relationship. Using the literature resistivity value of 5.82x10^{-8}ohm-m (*41-45*), the relationship

$$defects = \frac{fraction\ reduction\ thermal\ conductivity\ x\ \sigma}{SDR} \tag{9}$$

was used to determine the concentration of dislocations per square meter.

The uncertainty in the measurement method gave a $\pm$15% for the thermal conductivities. Conducting an exact propagation of uncertainty from that point to a retained damage value yields unacceptable results. Therefore these three measurements provide a direct statistically significant result. Using the percent reduction for each sample (Pac) the average thermal conductivity reduction is 25% with a 3% standard deviation and a 68% confidence. Averaging the dislocation concentration and taking the standard deviation from those values the results are $1.37\text{x}10^{17}$dislocations/$m^2 \pm 12\%$.

The greatest sources of uncertainty in the experiment were: apparatus configuration, rectangular prism geometry, and different wait periods between irradiation and measurement.

Addressing the first source of uncertainty, the apparatus failed to account for pressure resistance to heat flow and several times the sample worked to wick water (from ice melt) into the insulation along the sample. While the experimenter made note of wicking during the tests and discarded the resulting data any unnoticed water moving up the sample would generate significantly more error in a measurement. Also, pressure resistance to heat and electrical flow has been observed many times in the past and can affect the results of a measurement. This phenomenon was not accounted for.

In this case increased contact pressures would increase the flow of heat out of the sample while lower contact pressure could result in a reduction of heat flow. Failing to measure and account for contact pressure in this experiment is a major source of uncertainty in the test.

Addressing the second source of uncertainty, the time between irradiation and measurements, diffusion in aluminum and its alloys is a well-established phenomenon that contributes to aluminum's high resistance to radiation environments. An assumption was made (Vandermeer's void recovery equation applies) to account for diffusion of dislocations between irradiation and measurement, which was supported by additional testing in a latter section presented in this work. Taking a measurement each day on each sample over the 37 days following the irradiation would have provided recovery rate data and replaced assumption with observation, which would have clearly been a superior method.

While data collection is a much superior method compared to making assumptions, in this case larger time periods between irradiation and measurement directly resulted in lower dose rates to personnel. The same holds true for the number of measurements, more measurements mean higher dose. The balance between ALARA and data collection had to be established. While making assumptions instead of additional data collection is the third source of error, the assumption was deemed good enough to determine a baseline of retained damage for the thermal samples. The diffusion information could be collected using the in situ collection central Irradiator (CI) wire test and did not need to be collected from the thermal samples.

In situ wire testing would benefit from diffusion data collected using thermal conductivities; however, the dislocation retention baseline is sufficient to make the case for the proof of concept presented.

3.2.1.4 Conclusion

In conclusion these findings were observed:

1-Thermal conductivity of the aluminum alloy 2024 was significantly altered (~25% reduction) by low level fast neutron bombardment (10^{18-20} n/m^2) at room temperature (298 K).

2-Damage retention was on the order of ~10^{17} dislocations/m^3 at room temperatures (298 K).

3.2.2 Electrical Resistivity

3.2.2.1 Methods

Aluminum is a highly conductive material; hence small changes in the resistivity are difficult to measure. While the creation and diffusion of the dislocations at low fluence has not yet been measured in previous work, based on the specific dislocation resistivity (SDR) it is not unreasonable to believe electrical resistivity may change by as much as an order of magnitude given low diffusion conditions. The resistivity of AL 2024 is ~5.8×10^{-8} ohm-m. In order to achieve real time testing a wire with diameter<<length was monitored during and after neutron bombardment.

Al 2024 is not available in wire form so a 1% Si 99% Al wire was used instead with a resistivity of 2.7×10^{-8} ohm-m. This also provided an additional data point for an alloying factor to be used to describe radiation effects in aluminum alloys. As a more pure aluminum sample, the wire was expected to diffuse the dislocations faster and more completely than the 2024 alloy. Changes in the electrical resistance for the wire reflected the number of dislocations introduced in the wire during irradiation and the rate at which they were annihilated. The sample, while not Al 2024 material, is sufficient to provide data to examine dislocations retained and compare the alloys.

Higher dislocation density along with radiation enhancement increase diffusion rates. Diffusion is governed by thermodynamic equilibriums which is partially determined by alloy compositions and can be modeled. Generating data and postradiation dislocation equilibrium concentrations and adapting the existing model to those curves was the objective of the test. A derivation from first principles for each alloy is not part of the work; a theoretical explanation using existing models is, with necessary adjustments suggested to account for solute impurities in the lattice.

The data collected has only begun to fill the information gap for LFNI of aluminum alloys. Extensive work identifying the diffusion of neutron induced dislocations in multiple alloys is not necessary for a proof of concept. This concept was demonstrated with the comparison between the theory and the measurements described in this report using two alloys.

Thorough characterization from first principles, for nucleation and diffusion of dislocations in aluminum alloys would serve to advance scientific knowledge and provide useful information needed to develop NDI (using thermal or electromagnetic waves). However, it is beyond the scope of this work and is reserved for future projects.

The fine wire in situ measurements were successfully taken using the CI designed for this test and a multimeter connected to the leads at the top of the reactor tank. Detailed procedures are available in Appendix A.7.

Temperature corrections to the data were needed due to the temperature sensitivity of aluminum's electrical resistance. Unfortunately, the temperature profile in the UNEP reactor core during operations is not easily determined by experiment or model. The moderator flow and temperature profile is complex and would be altered by the specific core configuration being used.

Known characteristics of the reactor are inlet and outlet moderator temperatures, tank temperature profiles, and moderator flow rates. A temperature correction factor method was devised as follows:

At power (90 kW) prior to significant damage being introduced a resistance jump was observed (first 3-6 minutes). Using the resistance jump a factor of ~3.6^{0}C was calculated which could be added to the tank bulk temperature and assumed to be the wire temperature in order to account for the increased temperatures of the CI in the core. When the sample was in the core at power the temperature correction factor applied and when the sample was suspended in the tank above the core with the reactor shut down, the water temperature as reported on the control console was considered adequate for direct use.

The equation for wire resistance as a function of temperature is in Appendix D.5.1. The 3.6^{0}C correction factor was generated using a known Rref and Treff and assuming the Rcalc was the same as the measured resistance in the first 3-6 minutes of irradiation. The delta T was then solved for and used as the temperature correction factor.

The resulting data demonstrated the nucleation and equilibrium of voids in the material, giving a picture of dislocation equilibrium values and diffusion in a radiation enhanced environment. The diffusion of dislocations in a thermal (non-nuclear) environment was also measured post irradiation for several weeks. The thermal dislocation recovery measurements were consistent with historic void recovery kinetics (*38*) and the in situ measurements were consistent with existing models for aluminum diffusion rates, but not for void nucleation rates which will be addressed in the discussion section.

3.2.2.2 Results

Data collected on the wire during irradiation is contained in Figure 1. The data was collected in two reactor runs connected at t=103 minutes. Following the first bombardment, approximately one week passed before the second bombardment took place. The second bombardment began at t=103 minutes and continues to the end of the graph.

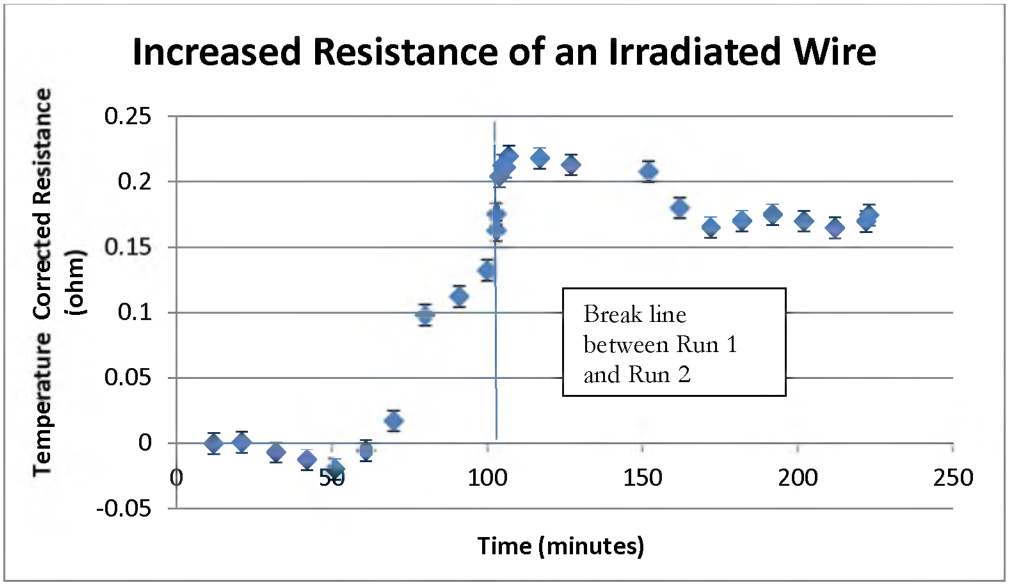


Figure 1
Increased Resistance of an Irradiated Wire

After the first hour the resistance began to climb steadily. Including interstitials and vacancies, the damage rate in the wire was 5.04×10^{10}dislocations/sec. The interstitials would have been eliminated quickly while the vacancies would have moved more slowly. The onset of vacancy loss to sinks appears to have taken about an hour, which is consistent with theory presented in the discussion section.

Each data point was taken in situ and the ability to take multiple reading at that exact time was not built into the apparatus. As a result the determination of uncertainty for the data was accomplished by examining the first 60 minutes of data when the properties were not expected to change. The data points were assumed to be part of a larger population and a standard deviation was taken and then assigned to all the data points.

Using the temperature corrected resistance of the wire, the number of dislocations was calculated by converting the wire resistance into a resistivity (see Appendix D.5.1) and then dividing that number by the SDR. The peak dislocation density was 6.4×10^{15}

dislocations/m^2. The final equilibrium for the last 75 minutes of the data collection was ~5x10^{15} dislocations/m^2. The dislocation uncertainty is a direct linear one to one percent correlation to the uncertainty in the resistance chart.

The wire experienced an increase in resistance. The same percentage increase in resistance would also correspond to a decrease in thermal conductivity as previously demonstrated with the WF law. What needs to be highlighted is the reduction in the thermal conductivity tests yielded a 25$\pm$3% result while this wire test yielded a reduction of 2.03$\pm$0.04%. The two samples were different alloys and therefore have a different thermal dislocation concentration retention threshold. The wire is by mole percent and weight 99% Al while the 2024 Al is by weight 92% Al and by mole percent 95% Al.

The theory that the solute atoms provided nucleation points for void formation is presented in the discussion section below. With the solute in the lattice functioning as a dislocation nucleation site, the 2024 has a concentration of 6.1x10^{17}site/m^2 and the wire has a concentration of 1.2x10^{17}sites/m^2 (determined by multiplying the atom percent of non AL species by the number of Al atoms in one m^2 identified in the equation below).

$$\frac{Al\ atoms}{m^2} = \left(\frac{1m}{2R_{al}}\right)^2 \tag{10}$$

Assuming voids in an aluminum alloy will first form on the non AL atoms in the lattice at low fluencies (10^{18}-10^{21} n/m^2), only 22% of the solute atoms formed voids in the Al 2024 and 4% of the solute atoms in the wire formed voids. The ratio between the two percentages is ~5.5. The fraction of solute atoms as potential nucleation points for radiation induced voids is also five times larger in the Al 2024 than in the wire. This observation suggests that the concentration of solute atoms in the metal may be used to model effects in different alloys.

3.2.2.3 Discussion

In order to set out an explanation of the observations made during this phase of testing the assumptions and theory must be presented.

Assumption 1- The lattice is composed of pure aluminum between solute atoms and can be modeled as a pure metal.

Assumption 2- The concentration of solute atoms = concentration of sinks. The concentration of solute atoms is orders of magnitude larger than traditional sinks like grain boundaries, voids, and clusters, therefore sinks are constant.

Assumption 3-Formation of clusters are ignored, see Assumption 2 for reasoning.

Assumption 4-No preferential absorption, and capture radius is ~ 10a. $ie\ r_{vs} = r_{is} = r_{iv} = 10a$

Assumption 5-Diffusion in and out of a specific volume is ignored.

Assumption 6-C_v^o is ignored for C_v balance equations. Where

$$C_v^o = N_o ln\left(\frac{-E_f^v}{kT}\right) \tag{11}$$

and is much less thanC_v.

From first principles the following equations can be derived (Was 37):

$$D_v = f\alpha a^2 v exp\left(\frac{S_m^v}{k}\right) exp\left(\frac{-E_m^v}{kT}\right) \tag{12}$$

Dv is the diffusion rate of vacancies through a pure aluminum lattice (f=1), a is the lattice constant, α=1 accounts for the diffusion mechanism in the fcc lattice for vacancies, ν is the Debye frequency, k is the Boltzmann constant, T is temperature in K, S_m^v is the entropy of vacancy movement and E_m^v is the energy of vacancy movement. Because $S_m^v << E_m^v$ it was made zero for calculations.

$$D_i = f\alpha a^2 v \exp\left(\frac{\mathrm{S_m^i}}{\mathrm{k}}\right)\exp\left(\frac{-\mathrm{E_m^i}}{\mathrm{kT}}\right) \quad (13)$$

Di is the diffusion rate of interstitials through a pure aluminum lattice (f=1), a is the lattice constant, α=1/2 accounts for the diffusion mechanism in the fcc lattice for interstitials, ν is the Debye frequency, k is the Boltzmann constant, T is temperature in K, S_m^i is the entropy of interstial movement and E_m^i is the energy of interstitial movement. Because $S_m^i << E_m^i$ it was made zero for calculations.

$$\frac{dC_v}{dt} = K_o - K_{iv}C_iC_v - K_{vs}C_vC_s \quad (14)$$

Vacancy point defect balance equation

$$\frac{dC_i}{dt} = K_o - K_{iv}C_iC_v - K_{is}C_iC_s \quad (15)$$

Interstitial point defect balance equation

$$K_{iv} = 4\pi r_{iv}(D_i + D_v) \quad (16)$$

K_{iv} is the rate constant of recombination of interstitials and vacancies.

$$K_{is} = 4\pi r_{is}D_i \quad (17)$$

K_{is} is the rate constant of loss of interstitials to sinks.

$$K_{vs} = 4\pi r_{vs}D_v \quad (18)$$

Kvs is the rate constant of loss of vacancies to sinks.

$$K_0 = Defect\ Generation\ rate \quad (19)$$

At Steady State for low temperature and low sink density:

$$C_v^{ss} = \sqrt{\frac{K_oK_{is}}{K_{iv}K_{vs}}} = \text{concentration of vacancies} \quad (20)$$

$$C_i^{ss} = \sqrt{\frac{K_oK_{vs}}{K_{iv}K_{is}}} = \text{concentration of interstitials} \quad (21)$$

Below are the equations which describe the timing of important events during irradiation:

$$\tau_1 = (K_0 K_{iv})^{-\frac{1}{2}} = Onset\ of\ mutual\ recombination$$

$$\tau_2 = (K_{is} C_s)^{-1} = Onset\ of\ interstitial\ loss\ to\ sinks$$

$$\tau_3 = (K_{vs} C_s)^{-1} = Onset\ of\ vacancy\ loss\ to\ sinks \tag{22}$$

The damage rate is given by:

$$\text{Eq}: R = 2N\sigma_s\phi\left(\frac{\gamma E_i}{4E_d}\right) \tag{23}$$

where the 2 accounts for both vacancies and interstitials and $K_o^v = K_0^i = \frac{R}{2}$.

$$N = 0.6x10^{23}\frac{atoms}{cm^{23}}$$

$$\sigma_s = 3x10^{-24}cm^2$$

$$\phi_{CI} = 2.19x10^{12}\frac{neutrons}{cm^2 - sec}$$

$$\phi_{FNIF} = 2.1x10^{11}\frac{neutrons}{cm^2 - sec}$$

$$E_{iCI} = 0.580\ MeV$$

$$E_{iFNIF} = 1\ MeV$$

$$E_d = 25eV$$

$$\gamma = \frac{4m_1m_2}{(m_1+m_2)^2}$$

$$m_1 = 1\ amu \qquad m_2 = 27\ amu \tag{24}$$

The void nucleation rate is calculated as follows: for this calculation the ratio between C_v/C_v^o is necessary to determine ΔG_n^o as it is a driving force for void nucleation (*37*). The more extreme $C_v \gg C_v^o$ becomes the more relevant it is as a driving force.

$$void\ nucleation = J_n = \rho^0(n)\beta_v(n)Z \tag{25}$$

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) = \text{void concentration of size n} \tag{26}$$

$$\beta_v(n) = \frac{4\pi R_v D_v C_v}{1+\frac{a}{R_v}} = \text{absorption rate} \tag{27}$$

$$Z = \left[-\frac{1}{2\pi kT}\frac{d^2(\Delta G_n^0)}{d(n)^2}\right]_{n_k}^{\frac{1}{2}} \sim 0.05 = \text{Zeldovich factor} \tag{28}$$

$$Sv = \frac{C_v}{C_v^o} \tag{29}$$

C_v^o is the equilibrium concentration of vacancy defects and C_v is the vacancy defect concentration in the sample.

$$\Delta G_n^o = n_k kT ln Sv + (36\pi\Omega^2)^{1/3}\gamma n_k^{2/3} \tag{30}$$

With n_k the number of vacancies in the void, k is the Boltzmann constant, T is temperature, Ω is the single atom defect volume, γ is the surface energy. N_o is the number of sites where a void can nucleate.

The void concentration

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) \tag{31}$$

at a given fluence is the equation of greatest interest from this series of equations as it provides the thermal equilibrium for the voids of size n, and will be addressed later in more detail in order to explain void formations in the alloys and propose an alloying factor.

Void growth can be described by the following equations. The equation indicates the voids would be growing at a rate of ~10^7 dislocations/m^3-sec, or a volume expansion rate of ~10^{-23} m^3/m^2-sec for the wire. This growth rate is extremely small suggesting millions of years before swelling would be significant (~1%) at these fluence levels. Void growth was determined to be too small to impact the observations in this work.

$$\frac{dR}{dt} = \frac{\Omega}{R}[D_V(C_v - C_v^V) - D_i C_i]$$

$$C_v^V = C_v^o \exp\left(\frac{2\gamma\Omega}{RkT}\right)$$

$$\Omega = \text{defect volume}$$

$$\text{R} = \text{void radius}$$

(Common form of the void growth equation) (31)

The time for the onset of vacancy loss to sinks in aluminum τ_3 was calculated to be ~1 hour using the assumptions and equations outlined above. The raw data demonstrates no increase in resistance for about one hour following the start of irradiation. This supports the assumptions validity and provides a good check for the test method against established theory.

Evidence provided by the calculation of $\tau_3$and the raw data indicates only the voids were visible using this method. This is not the case. Vacancy concentration at these fluence levels will be on the order of 10^{22} vacancies/m^3. Assuming each vacancy leads to a resistance of 1.1×10^{-25} ohms-m^3 the resistance change would have been almost immediately visible and the resistance would have dropped just as quickly with the cessation of bombardment. The near instant increase/decrease was observed during the introduction and removal of the radiation environment; however, the considered contributor was temperature change with the secondary being the vacancy concentration. As previously described, the temperature effect was adjusted using an empirical correction factor method. The factor would also have adjusted the vacancy concentration out of the data, making it appear invisible.

Given the rate at which vacancies are generated and then diffuse, the lasting damage was clearly something else. The lasting void recovery rate is shown in Figure 2 with the comparative points having been calculated from void recovery equations (*38*). The recovery rate equation closely describes the void recovery observed in the aluminum wire after the

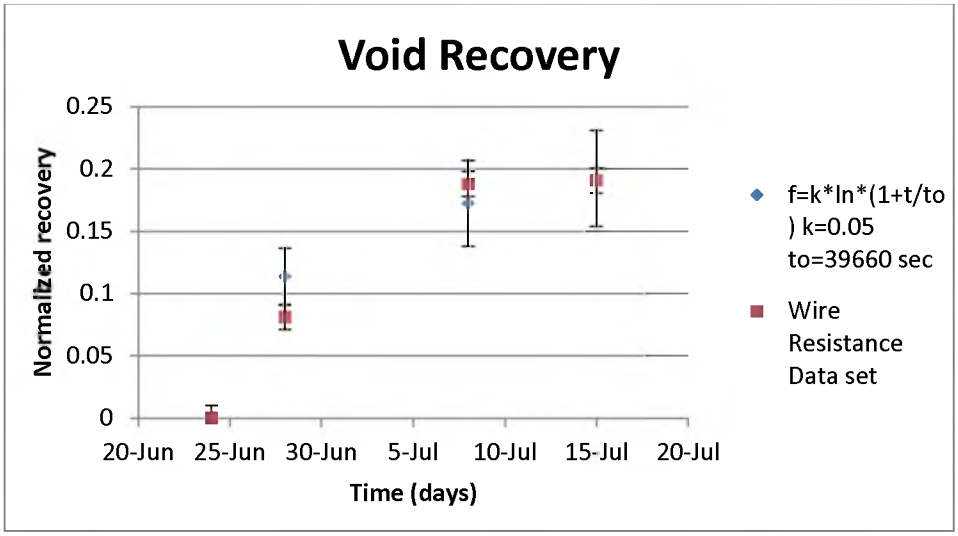


Figure 2
Void Recovery

bombardment. The dislocations nucleating into stable voids are the logical conclusion that follows from the data.

The uncertainty associated with the wire resistance is taken from the 0.007 ohm uncertainly described in the results section and depicted on the graphic in that section. The 0.007 ohm uncertainty was then propagated into the normalized data graph using the equation:

$$\frac{\delta q}{|q|} = \frac{\delta x}{|x|} + \frac{\delta y}{|y|} \tag{32}$$

The model itself does not have a clearly defined uncertainty. It was an empirical least squares fit model built to describe observed data (38). Assuming the model is $\pm$20% accurate the data collected here fits within the curve. For the purposes of the work here $\pm$20% will be assumed adequate.

Exponential Empirical model:

$$\frac{df}{dt} = -f\ \mathrm{K1}\ \exp - \left[\frac{Q_0 - Bf}{RT}\right]$$

$$Q_o = 144.5 \frac{kJ}{mole}$$

$$B = 27.3 \frac{kJ}{mole}$$

$$K1 = 1.41\ x\ 10^{10} \frac{1}{sec}$$

$$R = gas\ constant \tag{33}$$

This model is a first order diffusion rate controlled kinetic empirical system. The theory, the empirical model and the data collected in the literature all satisfactorily agreed (38).

Void nucleation rates in pure aluminum theoretically lead to concentrations orders of magnitude below what was measured in the wire and in the thermal samples. Examining the void concentration section (below) from the void nucleation equation, N_o represents potential nucleation points in the lattice, and ΔG_n^o represents the energy activation barrier for that void. Rather than taking N_o be the number of lattice sites, voids were assumed to nucleate mainly on the solute atoms and N_o was made to equal the number of solute atoms in the metal per unit area. The barrier to formation of a void on a solute atom is different than in a pure crystal so an alloying factor f was introduced.

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{fkT}\right) + N_o exp\left(\frac{-\Delta G_n^o}{kT}\right)$$

$$assume\ N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) \sim 0 \ll N_o exp\left(\frac{-\Delta G_n^o}{fkT}\right) \tag{34}$$

Void concentrations were calculated as a function of void size and then summed to determine the total value of the void concentration. The most stable void size was determined by graphing the energy barrier as a function of void size. The inflection point is 41. Voids nucleating below this point will dissolve back into the lattice as the energy curve favors that motion. Above that point the voids will continue to grow and the void growth equations apply.

In order to estimate the number of stable voids formed in the lattice, the inflection point on the energy barrier curve, 41$\pm$5%, (or 10% of the energy barrier range 0-141) was summed and compared to the experimental findings.

For the two different alloys measured (wire and 2024) the above method was applied and the resulting f factor was found to be 12 $\pm$ 0.8 (with ΔG_n^o calculated in joules). The uncertainty was calculated using:

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}} \tag{35}$$

In a pure metal f=1. The value 12 $\pm$ 0.8 reduces the activation barrier substantially below what would be observed in a lattice site surrounded by only Al atoms. The data demonstrated a correlation of different alloys using the solute atom concentrations combined with the empirical f factor.

While the f factor, combined with assuming nucleation mainly occurs at the solute atoms, described the results in this work very well, the assumptions are not always true. At very high fluence levels there are a number of reactions that can potentially take place from precipitates to pure lattice voids. Also, different impurities will likely create different energy barriers in the lattice. Those potentials were not explored as part of this work. The results showed that 1% Si alloy and 2024 were both adequately described assuming there were no preferential capture effects. The suggested model indicates that Al alloys could be accurately modeled using these assumptions.

In addition to evaluating the data generated in the CI using the wire and the thermal conductivity samples, the data generated in the FNIF were also explored. The FNIF has a significantly different energy profile and an order of magnitude lower flux as it is positioned outside the core and stocked with lead between it and the nearest fuel rods. Using the assumptions above and the experimentally determined activation barrier on the non-aluminum atoms, the samples for thermal conduction bombarded in the FNIF should have no property change at all-which was clearly not the case.

The Pac3 thermal conductivity sample had the same order of magnitude void concentration as the Pac1 and Pac2 samples. Using the void recovery equations and the time between the bombardment and the measurement, the postbombardment void concentration was estimated. These concentrations were then compared to the adapted void nucleation model. Pac1 and Pac2 fit well within the suggested void nucleation model results. Pac3 sustained more damage than the model suggested the samples would have received in the form of voids. The explanation likely lays in the simple physics of the system that dictates that diffusion is a function of flux, energy and cross section.

Radiation enhanced diffusion results when the lattice is essentially being mixed up by the introduction of energized particles. Those particles with their given energy levels are then converted to a damage rate, which is an estimation of the actual increased movement in the crystal as a result of the radiation, assuming effective isothermal conditions. As a result, the movement is a function of neutron energy, target cross-sections, and beam intensity. It makes sense the diffusion is directly related to damage rate more than any other factor given the conditions. While the samples were not kept strictly at one temperature, the conditions remained essentially stable (within 6 degrees C) enough to assume isothermal conditions.

Considering the concepts above, all three thermal conductivity samples were individually compared to the suggested model along with the wire. It was found that the Pac 3 sample was outside of the 12.0±0.8 f value. All the other samples fit comfortably in the range. Looking strictly at the damage rate it was observed that the FNIF created ~20% of the damage generated in the CI. The f value calculated for the Pac III thermal samples was 14.8, or ~20% higher than 12.

Steady state concentration of vacancies shown below drives void formation rate and is a function of dislocation generation rate, interstitial loss and vacancy loss. K_{iv} is a function of Cv and is known to be sensitive to radiation enhancement. Reduced damage rates will result in a reduced *Kiv* value and ultimately in a reduced f value.

$$C_v^{ss} = \sqrt{\frac{K_o K_{is}}{K_{iv} K_{vs}}} \tag{36}$$

Due to these observations K_{iv} was reduced to 20% of its original value (lower damage means lower diffusion) and the model with f=12 was applied to the Pac3 samples using 20% of the original Kiv value.

The void nucleation model and the Pac3 samples came into agreement as a result of adjusting the *Kiv* values to account for reduced mobility of vacancies in the FNIF. This result indicates the damage rate and the diffusion rate are linearly dependent with a one to one corresponding relationship. Unfortunately, there is only one data point comparing the FNIF and the CI. In order to further explore this observation, additional energy profiles and fluxes would need to be tested. Another method would be to theoretically derive the relationship between the damage rate and the radiation enhancement of *Kiv*.

3.2.2.4 Conclusion

A great majority of neutron bombardment studies of aluminum focus on void concentrations sufficient to generate swelling and elongation. Some work has examined aluminum under magnification and detected voids with bombardment as low as 10^{23}n/m^2. The results of this study demonstrate:

1-Void detection can be measured using resistance, and concentrations can be determined during and after irradiation, which can then be extrapolated to other property changes.

2-The concentration of retained dislocations in an aluminum alloy is a function of void energy formation and can be accounted for assuming nucleation occurs mainly at impurities in the lattice.

3-The nucleation of voids at solute atom locations has an energy activation barrier ~12$\pm$0.8 (with ΔG calculated in Joules) lower than the energy activation barrier at lattice sites in pure crystal.

4-Alloys can be correlated based on solute atom concentrations assuming:

1. Voids nucleate on the solute atoms
2. Sink concentrations are constant and equal to solute atom concentrations
3. Lattice is pure between solute atoms

5- The two irradiation facilities used in this test demonstrate that Kiv ratios have a one to one relationship with damage rate ratios

6-Aluminum alloys will experience significant property changes as a result of low fluence neutron bombardment $10^{18\text{-}20}$n/m^2.

3.3 Corrosion

3.3.1 Introduction

Corrosion in power reactors is an important issue for aging components. Aluminum is not a material found in power reactors because of its low melting point; however, aluminum is very common in research reactors where water purity is tightly controlled.

In addition to research reactors, aluminum is a candidate material for unmanned systems which will ultimately find themselves fielded in nuclear environments. Highly radioactive sites (or future sites) which have historically generated great interest are found in locations as varied from the moon to the bottom of the ocean. Exploration, development, or monitoring in such diverse locations drives the need to explore corrosion properties of candidate materials for systems intended to operate in those locations.

Corrosion can be measured using passive current density (PCD). Passive current density measurements are based on the electrochemical properties of the sample surface. A small current is produced during the corrosion process which can be measured to determine the rate of the process.

The PCD method has been used to study the oxide layer that forms on the surface of Zircaloy-4 (*23, 25*) in order to discover radiation effects on corrosion. The methods have been used to study many materials in a more conventional setting too.

The purpose of these measurements is to determine the impact irradiation will have on the corrosion rate of different engineered corrosion resistant oxide layers. Surface defects such as pits cracks and protrusions are known to enhance corrosion by providing a nucleation point for corrosion reactions to occur. Neutron induced dislocations are distributed throughout the material and not concentrated on the surface, leading to the question of whether or not those induced dislocations are sufficient to accelerate the corrosion process significantly.

Radiation is known to impact corrosion properties and passive current densities have been used to study both irradiated steel and zirconium alloys (*23, 25, 27*). While the data have been informative, the reports were not designed to model the corrosion rates' changes based on the micro structures, nor were they designed to demonstrate the effects at multiple fluencies. They did show clearly that neutron irradiation has an effect on a materials' resistance to corrosion.

Due to past work on other material it was believed the cumulative effect of surface dislocations will have significant corrosion rate impacts. Neutron induced dislocations have an even distribution throughout the material. There are very few dislocations on the surface itself but each surface dislocation adds a small increase to the reaction rate by providing nucleation points.

3.3.2 Methods

Work conducted to measure PCD described in this section was performed in the University of Utah's electrochemistry lab. Detailed procedures are in Appendix A.1. Procedures were developed under the instruction and supervision of the University's electrochemistry lab faculty using dummy samples. Detailed instructions for electrode construction are included in Appendix A along with experimental procedures, NaCl bath concentrations, and all other parameters used in the test.

To do the experiment, the sample was built into an electrode and then placed in a bath containing NaCl where the surface was corroded. The reaction produces a DC current. The corrosion of aluminum is governed by equilibrium between oxide layer destruction and oxidation of the base metal. Given the engineered layers there will not be an equilibrium established. The measurement will largely be based on the oxide layer destruction until a thin enough coating is reached for base metal oxidation to begin taking place in the solution. At that point the reaction will have removed the engineered coating and there will be equilibrium between the oxidation of the base metal and the dissolution of the surface. In order to determine the dissolution rate of the engineered coating the measurements were recorded prior to the removal of the engineered oxide layer. The basic idea can be observed in the two reactions and in Figure 3.

A simple model, the one that was used for the aluminum, was used to determine the number of dislocations in the oxide layers. This model, combined with the experimental results, was used to describe the effects of bombardment on corrosion properties.

3.3.3 Results

The raw data can be found in Appendix B.1 with the corresponding figures in Appendix E. The data were collected in Nano-Amperes vs. Volts and was converted to the rate of dissolution information below using Faradays Law:

$$Q = nFA$$

$$\frac{dQ}{dt} = \frac{nFdN}{dt}$$

$$\frac{i}{A} = nF\left(\frac{1}{A}\frac{dN}{dt}\right)$$

$$A = area$$

$$n = \#of\ electrons\ transferred\ per\ mole$$

$$N = moles \tag{37}$$

1) $2Al+3H_2O \rightarrow Al_2O_3+6H^+ +6e^-$

2) $Al_2O_3+6H^+ \rightarrow 2Al^{3+} + 3H_2O$

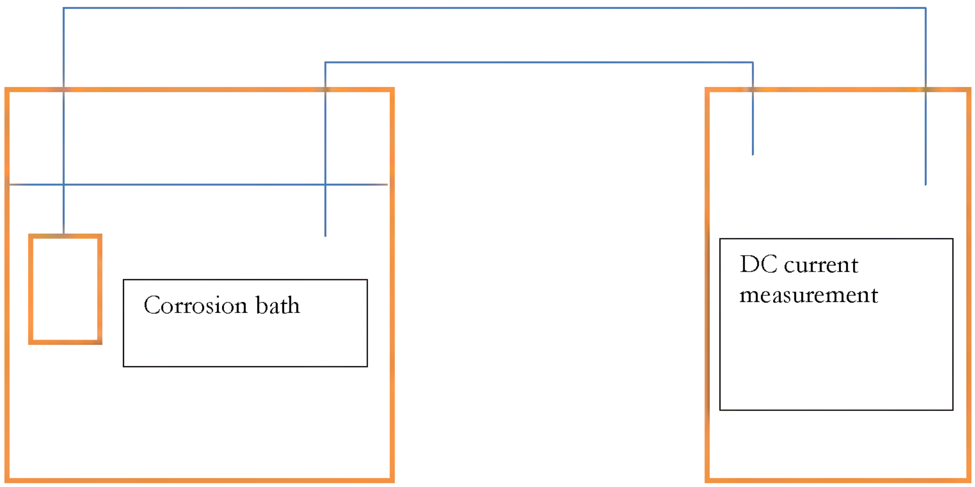


Figure 3
Passive Current Density Basic Diagram

Information in Table 2 is graphically depicted in Figures 4 and 5 in discussion section 3.3.4. The resolution of the data is an important issue for this data set. While results are consistent with the method the uncertainty leaves many of the calculated values indistinguishable from one another.

3.3.4 Discussion

Passive current density is primarily a measure of how the surface of the material is dissolving in the solution. The data provide a measure of the corrosion resistance. It is therefore not surprising at all that the natural oxide and the alodine treatments control

Table 2
PCD Results

	Pac1 moles/ cm^2-sec	**Uncertainty**	**Pac2 moles/ cm^2-sec**	**Uncertainty**	**Pac3 moles/ cm^2-sec**	**Uncertainty**	**control moles/ cm^2-sec**	**Uncertainty**
NO	1.76×10^{-10}	5.00×10^{-11}	1.67×10^{-10}	4.00×10^{-11}	2.15×10^{-10}	8.00×10^{-11}	2.04×10^{-10}	5.00×10^{-11}
Alodine	2.05×10^{-10}	3.00×10^{-11}	2.21×10^{-10}	9.00×10^{-11}	2.03×10^{-10}	4.00×10^{-11}	1.62×10^{-10}	3.00×10^{-11}
III	7.94×10^{-12}	4.49×10^{-12}	1.23×10^{-11}	5.00×10^{-12}	1.54×10^{-11}	6.60×10^{-12}	3.50×10^{-14}	3.50×10^{-14}
II	7.30×10^{-12}	4.00×10^{-12}	8.50×10^{-12}	7.60×10^{-12}	1.60×10^{-11}	1.50×10^{-11}	1.90×10^{-13}	1.90×10^{-13}

samples had the same rate of dissolution or that the Type II and the Type III performed in a near identical manner.

During the experiment it was observed that the alodine treatments lost their color as a result of irradiation and were nearly visibly identical to the untreated samples (indication that the alodine was mostly gone). The alodine was not designed to resist radiation at this level and with the increased diffusion and ionization of moderator; the coating appears to have been largely stripped away. With the coating largely gone, the sample would be expected to perform like the natural oxide.

Type III and Type II are comprised of thicker layers of aluminum oxide. The greater thickness of the Type III anodize would create a longer lasting barrier against the salt solution, however the initial material loss rate would be governed by the condition of the

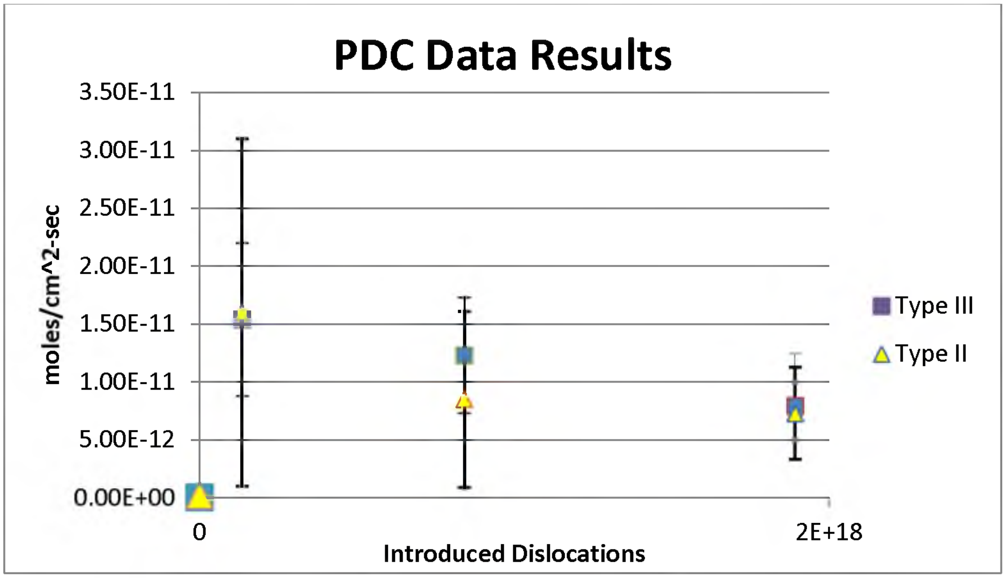


Figure 4
PCD Type III and Type II

oxide surface and not its thickness. The condition of the surface on the Type III and Type II given the same bombardment explains the near identical performance against material loss.

Looking at the PCD uncertainty data generated for the Type II and Type III alumina treatments in the results section, the data points with increasing damage are statistically indistinguishable, but are distinguishable from the control samples.

The dissolution rate for the control sample on the Type III is three orders of magnitude below the irradiated samples and the Type II control sample is 2 orders of magnitude below the irradiated samples. Clearly the bombardment had a large impact on the oxide layers ability to resist corrosion. The control sample condition of Type II and III led to the same corrosion resistance at the surface (i.e. the two data points fell within the uncertainty range of the other).

The irradiated samples of Type II and III, depicted in Figure 4, all jumped up to the ~10^{-11} moles/cm^2-sec range (a large increase in corrosion) with overlapping uncertainties.

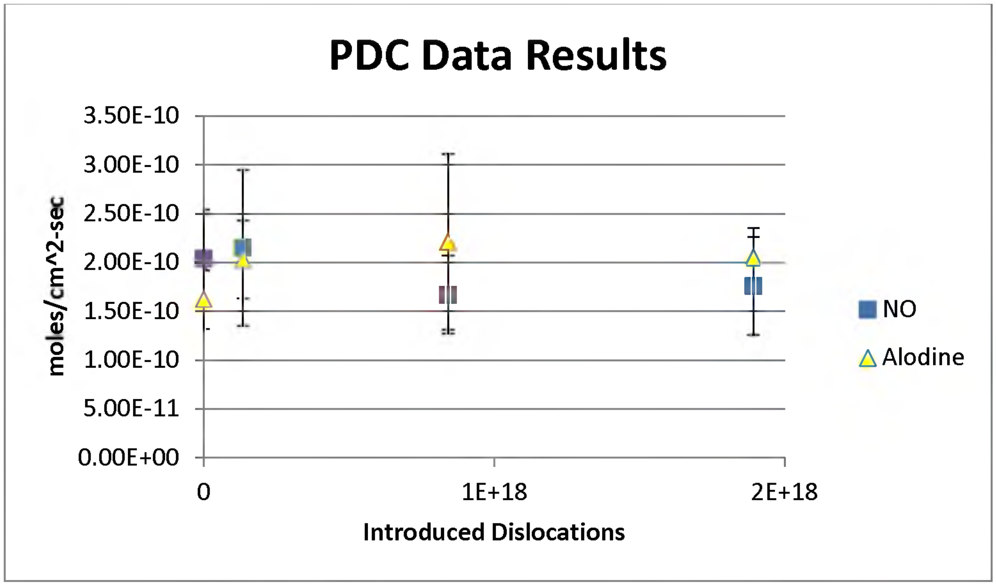


Figure 5
PCD NO and Alodine

Given the uncertainties associated with each data point it is interesting that both data sets peak at the lowest fluence and then diminish as the fluence increases. The trend may be explained by the possibility of different times between irradiation and testing. It is also possible that the oxide behaved in a similar fashion as the aluminum metal and simply reached an equilibrium concentration common to the three samples. Combining the Type III fluence level results yields an average of 1.2 $x10^{-11}$ moles/cm^2-sec with a stdev of $0.4x10^{-11}$ or 32%. Either explanation is reasonable; however, the magnitude of the uncertainty associated with each point makes a detailed explanation impossible.

Although the Type II and III were impacted by neutron bombardment, their degraded state performed an order of magnitude better than the un-irradiated alodine and natural oxide samples.

Figure 5 shows the material loss rate of the Alodine and natural oxide samples. Given the uncertainties, these numbers are essentially all the same. This indicates irradiation had no real effect on the corrosion rates of alodined aluminum or untreated aluminum. Given the less resistant corrosion barrier for the alodine and natural oxide, it is more likely the solution concentration was high enough to obscure any differences that may have been a function of irradiation in these samples.

Additional tests would be required to determine the ideal salt concentration for these types of samples. Additional testing on alodine would not be useful as the irradiation process mostly stripped the coating. Additional tests for the natural oxide may be useful but would likely serve only to prove that anodize resists corrosion in a hostile environment by even larger orders of magnitude (>2) given less concentrated solutions.

Unfortunately there are still many unknowns. For example, how far into the material a dislocation must be before is ceases to provide a nucleation point or how the removal of material exposes nucleation points generated below the original surface.

A thorough literature review has determined this kind of corrosion rate measurement at these fluence levels has not been made prior to this work for irradiated natural oxide aluminum, alodine, anodize Type II or III. The lack of data removes the possibility of a direct comparison to other work.

3.3.5 Conclusion

Corrosion measurements demonstrated the degradation of corrosion resistance in the anodized treatments. The degradation is likely the result of damage cascades generated in the first few atomic layers of the material, which are nearly invisible at the fluence levels tested.

The resolution of the test method was not sufficient to distinguish between the corrosion effects at the different fluence levels, but did demonstrate a degradation of corrosion resistance (two orders of magnitude) compared to the control samples. The fluence levels were either too close together to generate a clear difference or the induced dislocations recovered to an effective steady between irradiation and PCD testing. Both factors could have contributed, making the irradiated data points overlap.

Irradiated natural oxide and alodine samples did not demonstrate a degradation of corrosion resistance as a function of neutron irradiation. The alodine was effectively stripped from the samples during the irradiation and performed in the same range as the natural oxide. The salt solution the samples were tested in was likely strong enough to overwhelm any corrosion property differences resulting from the irradiation process.

3.4 Metal/Oxide Interface Measurement

3.4.1 Introduction

One subset of the corrosion measurements is the diffusion of oxygen through the oxide layer to form additional oxide beneath the engineered layer. The effects of neutron irradiation on the oxide/metal interface were demonstrated in a study on zircaloy (*26*). The corrosion process for aluminum is very similar to Zircaloy. While Al has been studied and the corrosion mechanism is well understood compared to many other materials, in an irradiated environment the data are still sparse.

Aluminum is highly reactive and exposed Al quickly forms an oxide. The oxide layer is stable and protects the subsurface from further oxidation. Assuming the oxide layer is not being eaten away by a corrosive environment, the primary driving force behind the oxide layer thickness is the diffusion of oxygen through the metal oxide. During irradiation, diffusion coefficients generally increase by large amounts (orders of magnitude). With the breaking of water molecules at the surface of the oxide layer and an increased diffusion of oxygen through the barrier, it is reasonable to believe additional metal oxide will form beneath the engineered oxide layer.

The oxide layer is the primary protection for the metal against corrosion. While the oxide layer thickness is not currently a critical design criterion, understanding how irradiation impacts the diffusion of oxygen through that layer and in the metal provides insight to lattice structure changes. Changes in thickness can potentially impact oxide structural stability as systems age and become more brittle and cycle thermally. A thicker layer will provide a better oxygen diffusion barrier but may introduce more stress/strain at the M/O interface and may become prone to cracking with thicker layers embrittled from radiation (which has been observed in other materials).

Two materials are present (metal and metal oxide), both changing in their own way as a function of fluence and flux. Material properties diverging with increasing dose is a potential long term corrosion threat which could be especially vulnerable to thermal cycling.

3.4.2 Methods

For this experiment, it was believed the oxide layer would likely thicken as a result of neutron irradiation and as a function of fluence up to a saturation point. At this point the layer will be sufficiently thick to have acquired a new equilibrium between thickness and diffusion. While the measurements have not yet been made, aluminum is being used in many radiation applications and reported events of aluminum failure from corrosion are practically non-existent. It stands to reason that there will be an equilibrium reached at some unreported fluence saturation point for aluminum.

In order to determine how much oxygen diffused through the oxide layer, weight measurements were taken prior to irradiation and afterward. There were no fewer than three samples at each fluence level in an aqueous environment during bombardment.

Total weight gain divided by the total surface area was used to determine the weight gain per unit area; the uncertainty was calculated by averaging the individual samples and then taking the standard deviation of those values.

The samples were all placed in an aqueous environment at the same time and removed from the aqueous environment at the same time. In addition, the samples which received the highest doses had to be irradiated over the course of several different runs to achieve the desired dose levels. The samples were irradiated in an aqueous de-ionized environment and then stored in that manner in an attempt to simulate the condition a material would encounter in a reactor system. Great care was taken to completely dry the samples prior to measurement. Detailed procedures for the test are in Appendix A.4.

3.4.3 Results

Results demonstrated an upward trend in weight gain as a function of damage rate. This was expected as the time required to meet the fluence objectives increased with increasing fluencies giving increased time periods of radiation enhanced diffusion. Figures 6-9 depict the data for each of the four sample types tested.

Type II anodize had a 62% increase in weight gain from the control sample to the Pac3 sample and a 45% gain from the control to the Pac1 sample.

The Type III coating experienced a 62% increase in weight from the control sample to the Pac1 sample. Natural Oxide weight gain is opposite from the engineered treatments. The weight gain was reduced by a factor of 85% compared to the control sample.

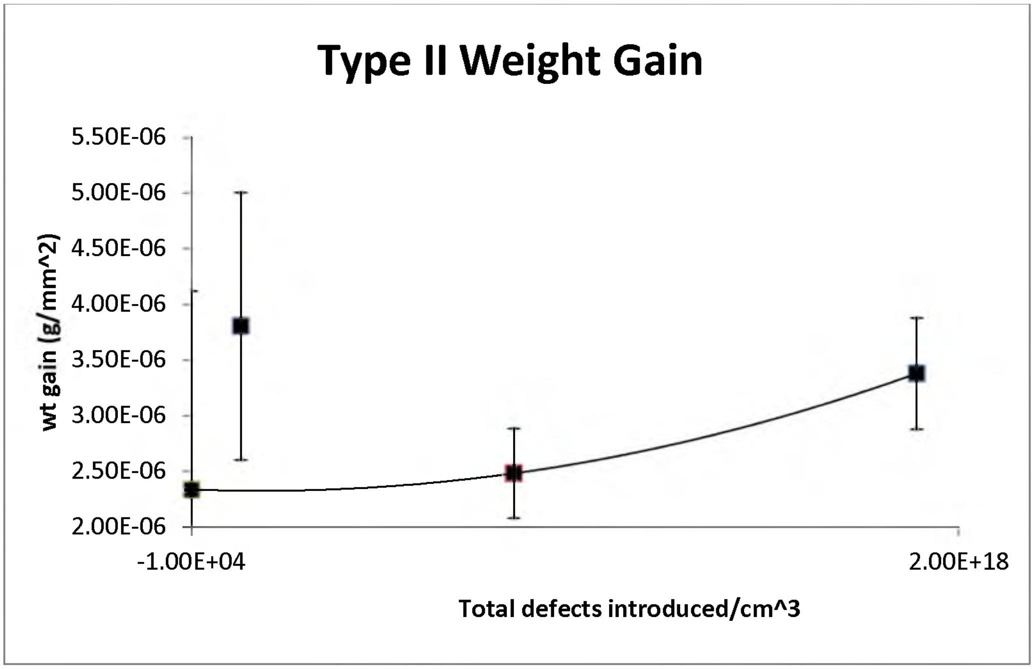


Figure 6
Type II Weight Gain

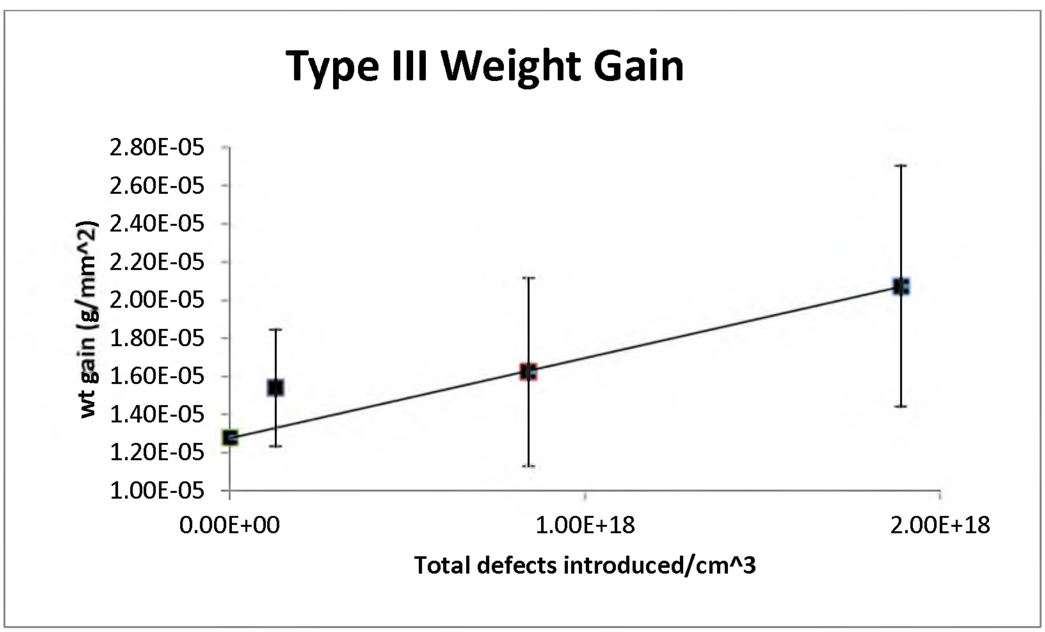


Figure 7
Type III Weight Gain

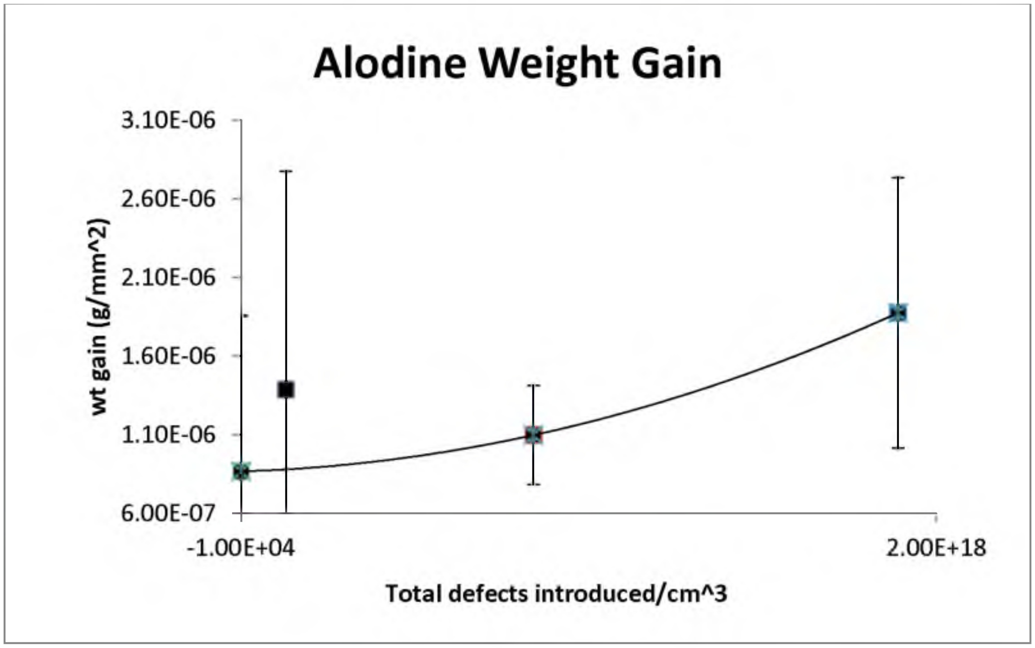


Figure 8
Alodine Weight Gain

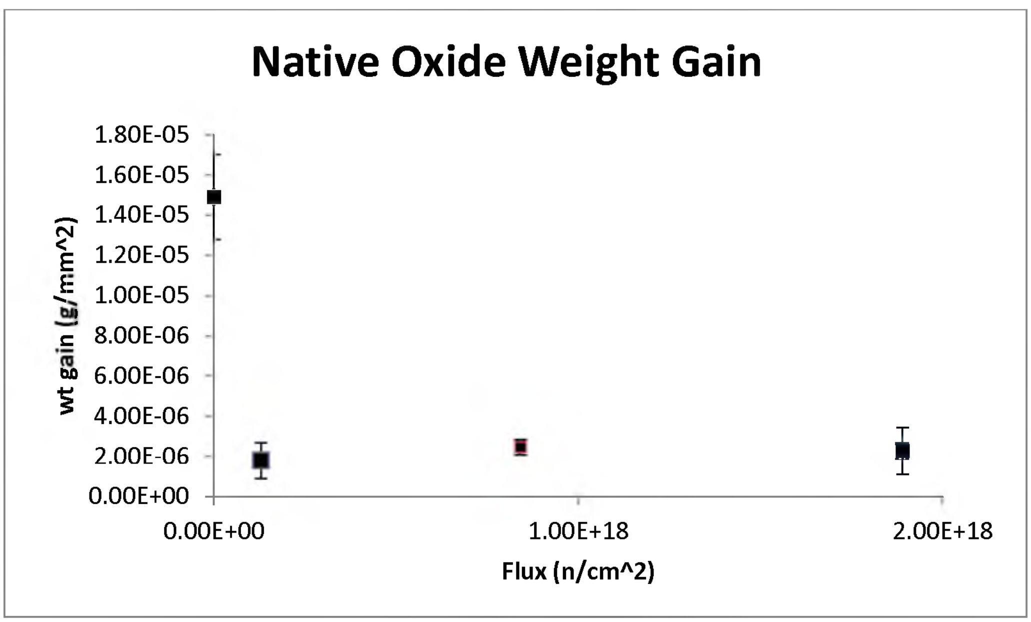


Figure 9
Native Oxide Weight Gain

Alodine is interesting because the samples were nearly stripped of the color indicative of the coating and in the PCD testing performed nearly the same as the natural oxide. For this test the Alodine Pac1 sample gained 116% weight compared to the control sample. This result is different from the natural oxide sample indicating the coating was still functional to some reduced degree following irradiation.

Uncertainties for the data contained in the Anodize Type III, Type II and the alodine all overlap. The uncertainties for the natural oxide coated irradiated samples do not overlap with the control sample. The results were calculated by summing the entire weight gain for the samples at each point and then dividing that sum by the total area. The uncertainties were calculated by taking the standard deviation of the individual results from each panel using the equation:

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n}} \tag{38}$$

The flux can be described as J=mass/area-time. Knowing the mass difference between the control samples and the Pac samples, the area and the time spent subjected to irradiation, the flux was calculated using:

$$Flux = \frac{\frac{(m_{post-rad} - m_{pre-rad})}{area} - \frac{(m_{control-final} - m_{control-initial})}{area}}{irradiation\ time\ (sec) \text{x}\ 16 \frac{\text{g}}{\text{mol}}\ \text{O}}$$

(See Appendix D section 14 for details) (39)

The uncertainty was propagated using

$$\delta f = \sqrt{\delta x^2 + \delta y^2} \tag{40}$$

The flux data are tabulated in Table 3 and graphically displayed in Figure 10.

Table 3
Flux Data

	Type III moles O/mm^2-sec	Uncertainty	Type II moles O/ mm^2-sec	uncertainty	AL moles O/ mm^2-sec	uncertainty
PC1	1.53x10^{-11}	1.23 x10^{-11}	2.01 x10^{-12}	3.57 x10^{-12}	1.94 x10^{-12}	2.53 x10^{-12}
PC2	1.50 x10^{-11}	2.15 x10^{-11}	6.29 x10^{-13}	7.94 x10^{-12}	9.99 x10^{-13}	4.51 x10^{-12}
PC3	3.77 x10^{-11}	4.51 x10^{-11}	2.12 x10^{-11}	3.11 x10^{-11}	7.48 x10^{-12}	2.47 x10^{-11}

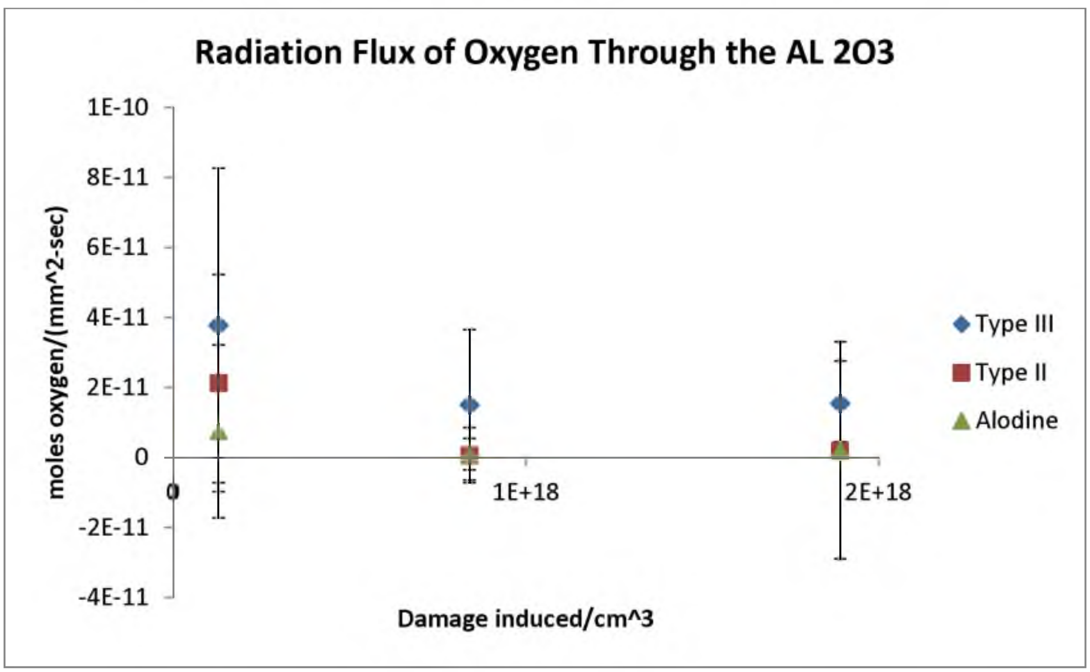


Figure 10
Radiation Flux of Oxygen Through the AL 2O3

3.4.4 Discussion

With exception to the Natural Oxide samples, the data had overlapping uncertainty values. However, the common trend between the anodize Type III, Type II and alodine demonstrate an unmistakable trend that cannot be ignored. In addition to the common trend for the samples bombarded in the CI, all the samples bombarded in the FNIF consistently fell above the line established by the data generated using the CI.

The FNIF provided neutrons with a 1 MeV equivalent beam. At this energy the cross section of aluminum changes very little from the 575 KeV value in the CI. For oxygen, the total neutron cross section increases from ~3.8b to 8.2b, a change of ~2.15. The damage rate would be increased but, as demonstrated by the figures above, not enough to account for the increase in the weight gain.

As the damage rate increases so too does the diffusion of dislocations. For Al_2O_3 the dislocation generation rate in the CI is 5.84×10^{19}dislocations/m^3-sec and the dislocation generation rate in the FNIF is 3.98×10^{19} dislocations/m^3-sec. The two facilities are generating dislocations at the same order of magnitude and as such should have approximately the same oxygen flux.

Additional factors affecting the flux can be examined using Ficks law:

$$J = -D(x)\frac{dC}{dx} \tag{41}$$

which describes the flux as a function diffusion, concentration and distance. The concentration of oxygen from one side to the other of the metal oxide (MO) will remain constant with the water on one side and the metal lattice on the other. In order to simplify the calculation the assumption that the diffusion coefficient is a function of total MO thickness was made. Therefore, the flux is a function of the MO thickness (as dC is constant), which is the well-established corrosion mechanism for aluminum.

The weight gain data indicate diffusion through the oxide layer is greatly enhanced and then reaches a steady flux as the MO thickens. This corrosion mechanism explains the greatly increase weight gain observed in the FNIF compared to the CI. The samples in the CI were subjected to 4-9 hours of bombardment while the FNIF samples experienced 1.2 hours of bombardment.

The oxide layer thickened most quickly in the first hour or so. Then the flux began tapering lower, indicating the nonconstant weight gain was being spread over a larger time. The data show the samples subjected to 9 hours of bombardment in the CI had oxygen fluxes about equal to the fluxes for the 4 hours samples, which suggest $J \neq 0$ when the irradiation was terminated.

Improved experimental procedures could possibly determine reductions in flux rates obscured in the present data. Had the samples been bombarded in one hour blocks and measured following each bombardment the flux could be observed with time and damage more clearly. The data presented here are a total weight gain for the entire irradiation period. While the sample sets demonstrated common trends, the small sample panels generated large relative errors casting uncertainty on the results. Larger panels would have reduced those uncertainties.

The ending thickness can be calculated as such:

$$\frac{wt\ gained}{alumina\ density} = volume\ gained \tag{42}$$

$$\frac{volume\ gained}{area} = thicknes\ gained \tag{43}$$

This calculation is limited because the ending thickness was collected as a single data point which effectively makes dx and D(x) both constant, which is not exactly the case. In order to determine what the diffusion was for this specific case, the nonirradiated weight gains were subtracted out of the irradiated sample totals. Also, it was assumed that the oxygen concentration was $3.6\text{x}10^{-5}$moles/mm^3, the mole concentration of oxygen in water.

Figures 11-13 graphically depict the diffusion constants calculated for each of the sample sets at each of the fluence levels. The x axis corresponds to time in the facility and damage. The three times for the data are 1.2 hours, 4 hours and 9 hours.

The uncertainty was calculated using the equations:

$$\delta t = \frac{\delta x}{\rho} \tag{44}$$

$$\delta D = \frac{\delta t \cdot J}{dC} \tag{45}$$

where δx is the uncertainty of the weight gain in mass/area, ρ is density, and δt is the

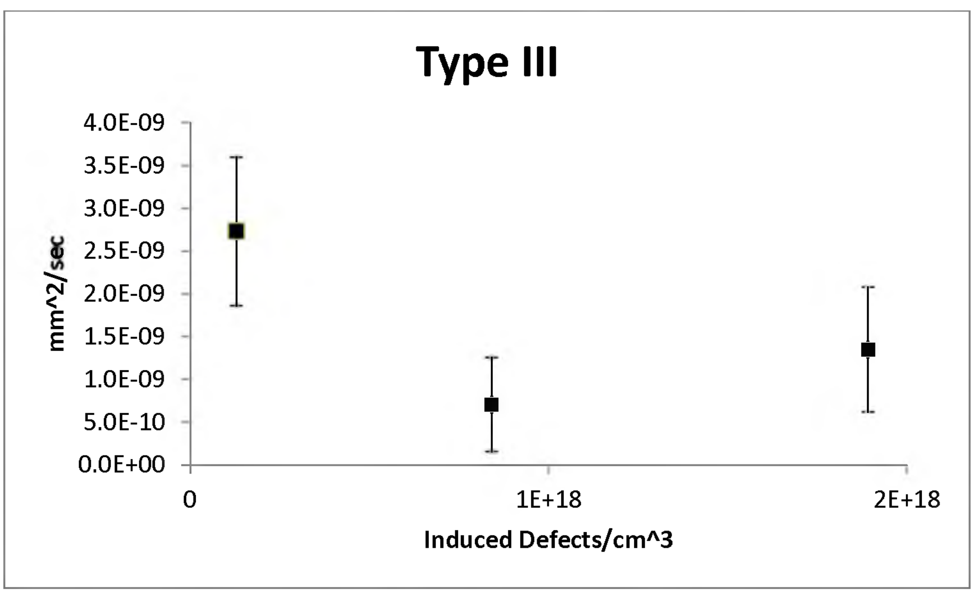


Figure 11
Type III Diffusion Coefficients

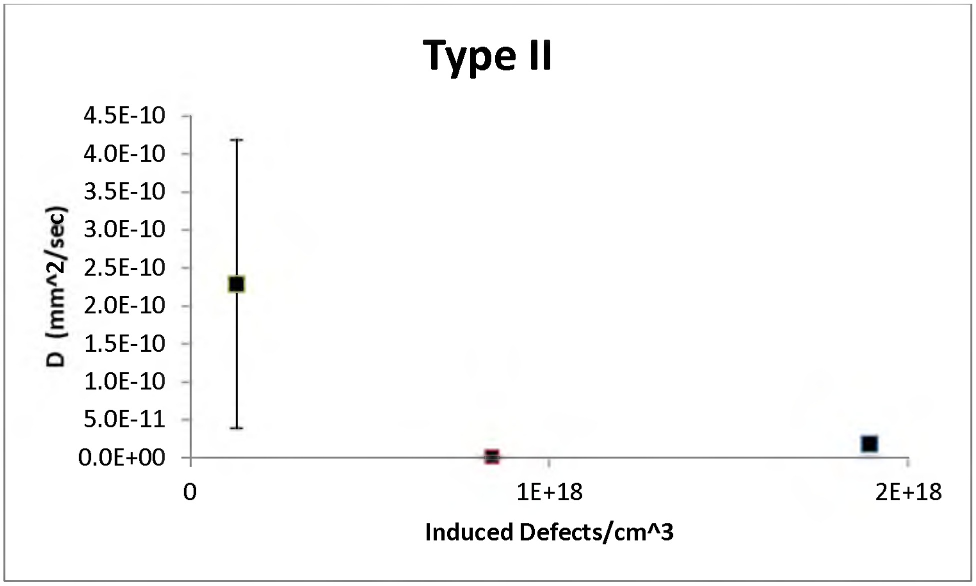


Figure 12
Type II Diffusion Coefficients

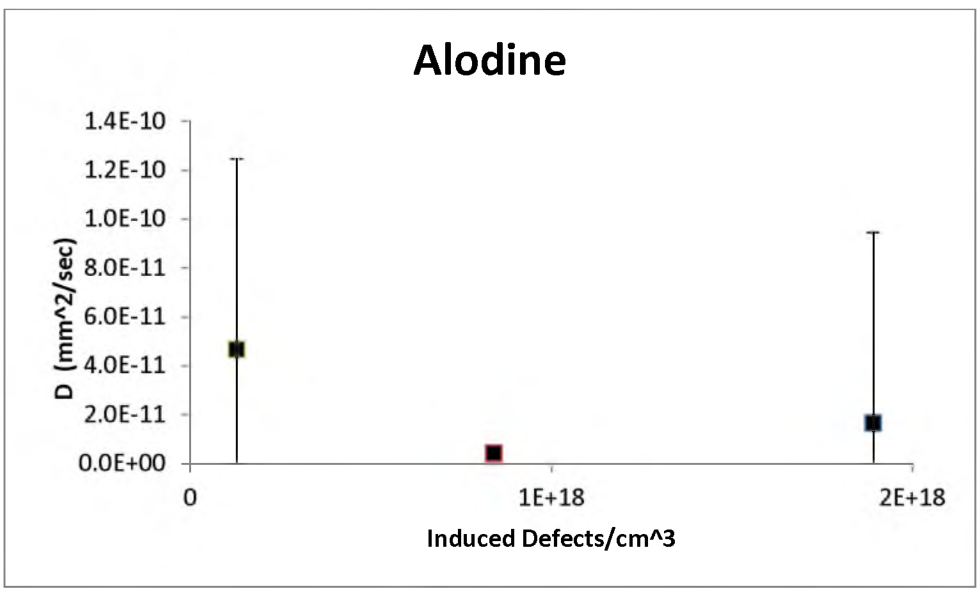


Figure 13
Alodine Diffusion Coefficients

uncertainty in thickness. δD is the uncertainty of the diffusion coefficient, J is the flux, and $dC$is the concentration of the oxygen in the water. The data from Figures 11-13 are shown tabulated in Table 4.

The final note for discussion is the results from the test conducted on the Native Oxide samples. The weight gain tests for these samples did not yield expected results. The data indicated an opposite response from the expected outcome when the irradiated samples experienced weight gain an order of magnitude lower than the control samples.

What was even more unexpected was the precision on the native oxide samples was much better than for the treated samples. The data therefore have a much higher degree of confidence.

The Native Oxide data indicates the irradiation process stabilized the oxide layer and inhibited oxygen diffusion below what a conventional (non-nuclear) environment would generate. Any explanations derived from experimental design would be systemic across all

Table 4

Diffusion Data

Diffusion mm^2/sec	III	Uncertainty	II	Uncertainty	AL	Uncertainty
PC1	$1.3x10^{-9}$	$7.3\ x10^{-10}$	$1.9\ x10^{-11}$	$7.5\ x10^{-12}$	$1.6\ x10^{-11}$	$1.3\ x10^{-11}$
PC2	$7.1\ x10^{-10}$	$5.5\ x10^{-10}$	$1.1\ x10^{-12}$	$1.9\ x10^{-12}$	$4.1\ x10^{-12}$	$2.4\ x10^{-12}$
PC3	$2.7\ x10^{-9}$	$8.7\ x10^{-10}$	$2.3\ x10^{-10}$	$1.9\ x10^{-10}$	$4.7\ x10^{-11}$	$7.8\ x10^{-11}$

the samples for all four coating. Any explanation leading to inhibited diffusion would fail to account for the trends demonstrated by the samples coated with Type II, III and alodine. One possible explanation is the potential for the native oxide coat to be far more sensitive to surface area change, as a function of irradiation, than the three engineered surface treatments. A single measurement for surface area was taken prior to irradiation based on the assumption that the area would change a very small amount compared to the weight gain. Given the unexpected result from the native oxide layer, that assumption may have been untrue for the sample set.

The observed phenomenon regarding the inhibited weight gain by native oxide in the radiated environment warrants additional exploration in future experiments which would validate the observation and provide explanation or relegate it to an unrepeatable anomaly.

3.4.5 Conclusion

Weight gain data yielded expected trends. There was increasing weight gain with increasing fluence. However, as the oxide layer thickened the rate at which oxygen was permeating the boundary appeared to slow.

These measurements suggest radiation enhanced diffusion occurs and effectively makes the boundary more permeable which thickens the oxide layer and ultimately chokes the rate at which the oxygen is moving into the metal.

While the data show expected trend and delivers order of magnitude expectations for weight gain, flux and diffusion coefficients, the uncertainty in the test results precludes any credible conclusion for flux and diffusion data.

3.5 Irradiation Facility

The UUTR facility is a reactor located in the basement of the Merrill Engineering Building. The reactor has three irradiation facilities; The FNIF (fast neutron irradiation facility), TI (thermal irradiator), and the PI (pneumatic irradiator) or "rabbit". The FNIF would be the ideal facility to use for irradiation fluencies below 10^{20} n/m^2 because 2.1×10^{15} fast neutrons/m^2-s is generated in that facility. Reaching 10^{21} n/m^2 is possible but realistically takes too long to be acceptable to the program.

The FNIF facility is an Air Force (AF) facility located in the UNEP TRIGA reactor which John Benion (*35*) designed and qualified in coordination with the AF and NIST. The facility sits outside the reactor core with a wall of lead between the facility and the closest fuel rods. The average neutron flux in the facility is 0.4 MeV and the neutron equivalent beam is 1 MeV at 2.1×10^{15}n/m^2-sec. The characterization of the facility is extremely detailed and the energy profiles clearly defined. The facility required no characterization to accomplish this work.

The A ring at the center of the core is generally unoccupied and an irradiation facility was designed to fit in that slot. The flux in the center of the core is 2.19×10^{16} n/m^2. At this level, 10^{21} n/m^2 can be achieved in about 8-10 hours.

Designing the facility required detailed drawing of the core, which is not included in this report but is available at the UNEP facility. After creating a design for a Center Irradiator (CI), MCNP5 modeling of the reactor had to be accomplished to determine the reactivity of the Central Irradiator (CI), which displaced the moderator in that volume space. Also the neutron energy profile was modeled for the cavity in the center of the CI where samples were intended to be placed.

The loss of reactivity resulting from the displaced moderator was small but enough to establish a firm requirement that the CI must not be removed from the reactor until the reactor is completely off. In addition to the stay in place requirement, the CI was not to be inserted during operation either, the reactor had to be brought to power and then powered down with the CI in place. A detailed drawing of the CI facility is available in Appendix C.

Historically, the A ring has been used as an irradiation facility and has been characterized with a cadmium ratio experiment and flux measurements. Kevin Weaver (*36*) described the facility with a $2.19 \times 10^{16} n/m^2$-sec and a cd ratio of 3.42; unfortunately detailed designs including dimensions and material used were not identified. While the testing provided data sufficient for Weavers work, the experimental data were not sufficient to make the calculations needed for the work in this report. MCNP5 had to be used to model the CI designed specifically for the tests conducted for this report and Weavers work was used to benchmark the model.

Two separate CI designs were built; the first was a facility for simple irradiation, the second was designed to take data from a sample during the irradiation process. The first design was for irradiating the corrosion, weight gain and thermal conductivity samples. The second facility was designed to measure electrical resistance during and after neutron bombardment. Because larger wires have lower resistivity, 2 gauge copper wire was used as the leads penetrating the center cavity. The copper wire will experience neutron damage but will contribute so little resistance (below detectable limits) due to the large diameter that the only contributing effects will be isolated in the sample wire (.001" diameter).

Mechanical strength was also determined for the CI facilities. The structural strength of aluminum at the given design thicknesses is capable of tolerating depths and temperatures that far exceed the environment the CI facility will see in the TRIGA. The sealing epoxies used to cover the wire penetrations into the center of the CI are also sufficient to withstand the operating environment. The O-ring and torque values for assembling the two part CI was not determined, however two gaskets had to be used to waterproof the inner cavity and the CI had to be firmly hand tightened during assembly.

The epoxy used to seal the leads penetration point into the inner cavity is highly questionable for continued performance in a radiation environment. While no analysis has been conducted to determine the possible life expectancy of the material, a similar epoxy was used to coat the edges of the weight gain samples. Those coatings experienced embrittlement and several cracked and broke following the irradiation phase of the testing. It is recommended that the epoxy sealing the lead penetrations be replaced prior to additional "in situ measuring CI" facility use.

Following the design of the CI, the MCNP5 model was provided to the reactor supervisor and the UNEP for approval. Following approval, the CI was constructed and then tested in the core. A flux map was generated and is in Appendix E. The MCNP5 modeled energy profile for the CI is in Appendix C.2. The average neutron energy was calculated to be 0.58 MeV with a flux of $2.1 \times 10^{15} n/m^2$-sec.

3.6 Analysis of Variance (ANOVA)

An analysis of variance was not included in the preplanning for this work but was calculated following the collection of data to provide additional confidence to support statistical assertions made in this report. Unfortunately an ANOVA method on the electrical conductivity tests data could not be conducted based on the collection and sampling of the wire data. Improved quality of future work would warrant additional measurement taken at each time step (no less than five) and at least three separate wires would need to be tested.

The other three data sets had an ANOVA applied to them with the results presented and discussed in the sections below. The ANOVA software used to conduct the data processing was the Microsoft excel 2007 ANOVA tool.

3.6.1 Thermal conductivity ANOVA

The thermal conductivity test consisted of three samples. Each sample was subjected to a different level of radiation and a different diffusion period, meaning the time between irradiation and measurement was not the same across the samples. In addition to multiple variables potentially affecting the conductivity there was a very small number of tests completed following the irradiation given ALARA considerations.

The three samples were measured for the high thermal conductivity geometry a total of six times (two for PAC2 and four for PAC 1). The ANOVA could not be run on the high thermal conductivity geometry give a zero variance for one of the data sets. Given the exact same average, the data sets were assumed equivalent and all incorporated into the same pre-rad data column. The low thermal conductivity geometry was tested a total of 12 times (three for PAC1, four for PAC2 and five for PAC3). The ANOVA tool analyzed the data and returned an $F_{crit}=4.25$ and an $F=1.37$ giving a P-value of 0.30. The Fcrit is a threshold value which if F exceeds indicates the data sets are statistically different with a 95% confidence. A P-value of $n<0.05$ is another measure of the same result while $n>0.05$ provides evidence the sets are not different. In this case the analysis provided evidence the data were statistically the same, which makes sense because the three samples had not been irradiated yet. Comparing the high and low thermal conductivity geometry resulted in a P-value of 6.48×10^{-9} which clearly shows that the thermal diffusion out of the sample was geometry dependent. The geometries had to be kept consistent in the measurements prior to irradiation and after.

Due to the limited number of measurements taken following irradiation the comparison of PAC1, 2, and 3 to their pre-radiation measurement resulted in P-values of PAC1 P-value=0.12, PAC2 P-value=0.12 and PAC3 P-value=.01 for the low side conductivity and the high side at PAC1 P-value=0.29 and PAC 2 P-value=incalculable with no data for PAC3. The only data point with a 95% confidence of being different was the low side PAC3. Because there was no significant difference between the samples based on radiation level there could be not be any difference based on cooling time either, given the radiation level and cooling time were grouped together in the same data.

Given the similar percent changes in conductivity between the high and low geometries and very close postradiation values of the thermal conductivities across the three radiation levels for the low geometry, a comparison of the postradiation high and low geometries compared to the preradiation measurements was conducted. The resulting P-value for the pre and postradiation low geometry thermal conductivity was P-value=0.002 and for the high geometry P-value=0.050.

This result provides evidence that the pre and postradiation measurements are statistically different based solely on whether or not the sample was irradiated. In order to achieve the 95% confidence needed for the test more than one or two measurements needed to be taken and it is likely the individual comparisons would yield the same result given additional measurements and a lower F-Crit threshold burden. An explanation of why the irradiation was the primary driver and not dose level or recovery time in these data is available in the thermal conductivity discussion section.

3.6.2 PCD ANOVA

Conducting an ANOVA on the PCD data for the PAC1-3 and control data sets yielded for the Alodine surface treatment P-value=0.42, for native oxide P-value=0.66, for Type II P-value=0.15, and for Type III P-value=0.003. Based on these values, the only data with a unique set were the Type III. For the Type III data an additional analysis was conducted comparing PAC1, 2, and 3 which yielded the result P-value=0.15, which identified the control (NI) sample as the unique data set. Additional work attempting to identify any effect cooling time (which was different for PAC1, 2 and 3) may have had on the samples was determined unnecessary due to the fact that the samples were statistically indistinguishable based on radiation level, which also corresponded to cooling time.

Due to the nature of the radiation damage and the recovery effects observed in the thermal conductivity and electrical resistivity experiments of the aluminum metal, the possibility of similar effects in the aluminum oxide drove a look at a simple preradiation data (control of NI) vs. postradiation data (PAC) ANOVA. The result were for the Alodine surface treatment P-value=0.097, for Natural Oxide P-value=0.59, for Type II P-value=0.066 and for Type III P-value=0.0019. The result still demonstrated the Type III data were statistically different while the other three surface treatments were not. Observing that the P-values all were reduced with the exception of the native oxide data by combining all the post radiation data supports the assertion that there is a differences in response if a lower confidence level is accepted. While none of the three non-Type III samples met the 95% confidence level for having statistically significant pre and post radiation responses, a reduction to 90% confidence would include the Type II data and having a significant post radiation response.

3.6.3 Weight Gain ANOVA

Weight gain measurements were intended to demonstrate the enhanced diffusion of oxygen through the oxide layer. These measurements were supposed to establish order of magnitude oxide layer thickness equilibrium changes as a function of the fluence.

An ANOVA calculation was conducted on the data collected for PAC1-3 and the control samples with the following results, Type III P-value=0.64, Type II P-value=0.10, Native Oxide P-value=6.9×10^{-13}, and Alodine surface treatment P-value=0.74. The Native Oxide data, when examined closely, clearly demonstrated the control (NI) data was the unique collection among the sets.

A comparison of each surface treatment type was done based strictly on control vs. radiated weight gain response. The results were for Type III P-value=0.96, Type II P-value=0.22, Native Oxide P-value=1.68×10^{-15} and for the Alodine treatment P-value=0.98. These results provide additional evidence that the data, with the exception of the Native Oxide, is completely statistically indiscernible.

Unfortunately the weight gain of the Native Oxide was opposite of expected results. Experimental error is the most likely cause. The surface area was measured pre-radiation and assumed to be constant. If the surface of the oxide layer was sensitive to bombardment resulting in protrusions and divots more so than the other treated surfaces the opposite result could potentially be explained. Given the large uncertainty and the non-statistically unique data no real conclusions can be formed from the results of the measurements made for weight gain. In the weight gain section of the main report the case was made for significance based on the common upward weight gain trend between the three treated surfaces even though the uncertainty was high and confidence for the data of each individual treatment type was low.

SECTION 4

CONCLUSIONS

The conclusions of this work are:

1-Thermal conductivity of the aluminum alloy 2024 was significantly altered (~25% reduction) by low level fast neutron bombardment (10^{18-20} n/m^2) at room temperature (298 K).

2-Damage retention was on the order of ~10^{17}dislocations/m^3 at (298 K).

3-Void detection can be measured using resistance, and concentrations can be determined during and after irradiation, which can then be extrapolated to other property changes.

4-The concentration of retained dislocations in an aluminum alloy is a function of void energy formation and can be accounted for by assuming void nucleation occurs mainly at impurities in the lattice.

5-The nucleation of voids at sites solute atom locations has an energy activation barrier ~12$\pm$0.8 (with ΔG calculated in Joules) lower than the energy activation barrier at lattice site in pure crystal.

6-Alloys can be correlated based on solute atom concentrations assuming:

1. Voids nucleate on the solute atoms
2. Sink concentrations are constant and equal to solute atom concentrations
3. Lattice is pure between solute atoms

7- The two irradiation facilities used in this test demonstrate that Kiv ratios have a one to one relationship with damage rate ratios

8-Aluminum alloys will experience significant property changes as a result of low fluence neutron bombardment $10^{18\text{-}20}$n/m^2.

9-The resolution of the corrosion test method was not sufficient to distinguish between the corrosion effects at the different fluence levels, but did demonstrate a degradation of corrosion resistance (2 orders of magnitude) compared to the control samples.

10-Irradiated Natural Oxide and alodine samples did not demonstrate a degradation of corrosion resistance as a function of neutron irradiation. The alodine was effectively stripped from the samples during the irradiation and performed in the same range as the natural oxide. The salt solution the samples were tested in was likely strong enough to overwhelm any corrosion property differences resulting from the irradiation process.

11-Weight gain data yielded expected trends. These measurements suggest radiation enhanced diffusion occurs and effectively makes the boundary more permeable which thickens the oxide layer; however the uncertainty in the test results precludes any credible conclusion.

The MCNP5 files were struck from this report per reactor supervisor request and would only serve to clutter the report. The UNEP TRIGA reactor is well characterized; the addition of the input and output files would add no new information to the UNEP program. The characterization of the CI which is unique to this work is contained in Appendix C. The energy profiles were generated using MCNP5 models and the flux value was experimentally measured for the CI.

The raw data identified in the deliverables are in Appendix B. The new CI equipment resides in the UNEP reactor facility and is detailed in Appendix C with the flux map data in Appendix B.4.

SECTION 5

FUTURE WORK

Follow-up work would involve improved apparatus and uncertainty reduction. The thermal conductivity measurements were affected by the dimensional variability. Using bar stock with more consistent geometry would yield measurements not dependent on the configuration of the sample. Also, the apparatus could be improved by making the contact pressure constant and impeding any wicking action on the sample.

Resistance measurement would be improved by incorporating a thermal couple in the test cavity of the CI so the temperature would be measured not approximated. Also additional wire tests could be conducted to improve the confidence in the results.

The proposed f factor in the equation:

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{fkT}\right) + N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) \tag{46}$$

could be examined using a wider range of alloys. This could be accomplished using the thermal conductivity or the resistance of a wire. While the f factor explained the results in this work very well, data from a wider range of alloys would serve to quantify the applicability of the f factor and determine the extent to which it could be used for all aluminum alloys.

The differences between the samples processed in the FNIF and the CI were significant. When explored, the results appeared to indicate the value of the rate constants governing the loss of interstitials to vacancies was linearly dependent on the damage rate being generated in the facility. Two methods for exploring this observation are possible. The first is to derive the dependence of the damage rate on *Kiv* and second is to experimentally determine the dependence.

While both seem trivial, the experimental method would require the development of testing using a wide range of fluencies and potentially different neutron flux energy profiles. The derivation method would require a significant amount theoretical work in order to mathematically demonstrate the relationship. Both methods to explore the relationship are beyond the scope of the work presented here; however, the simplest explanation of Pac3 behavior irradiated in the FNIF is the 80% reduction of damage leading to an 80% reduction in radiation enhanced diffusion for *Kiv*.

Additional work for weight gain as a result of irradiation is required in order to make any quality determinations. The uncertainty in the work here was too great for a quality conclusion to be made. The samples in this test were ~0.1 in^2. The data did appear to demonstrate trends that were expected (with the exception of the Native Oxide); however, the uncertainties overlapped consistently.

Improving the precision of the data could be done by using larger samples. Larger samples would result in larger weight gains, which would be easier for lab scales to measure. Also the small variation due to air currents and water contained in the epoxy coated edges would be relegated to insignificance. Samples measuring in the ft^2 would fit easily in the FNIF and would likely yield much higher quality radiation enhanced diffusion data results. Additional considerations for increasing precision would be to make better area measurements on the panels before and after irradiation. The panels were subjected to neutron bombardment and certainly had an increase in protrusion and divots on a microscopic level. The increase in surface area (if extreme enough) could result in what would appear to be a negative weight gain when the area was assumed to have not changed.

A repeat of the native oxide samples would also serve to validate the anomaly of weight gain inhibition observed in this work. The Native Oxide result was unexpected. Repeating the test for verification would result in understanding a potentially unique radiation diffusion inhibition or serve to demonstrate nonrepeatability of the result generated in this test.

Oxide layer thickening could also be better understood by taking measurements from samples with much less time in the irradiator. The greatest weight gain occurred at the front end when the enhanced diffusion began. Measuring the same sample over a series of irradiations would better define the weight gain process.

In addition to the corrosion effects already discussed exploration of the gamma effects v.s. the neutron bombardment effects should be considered during any future experiments performed. The UUTR irradiation facilities have significant gamma ray fluence in addition to the neutron environment. While the vast majority of energy deposited in the material will result from neutron collisions, separating out the gamma energy deposition would provide for more exact corrosion property data.

Any additional work conducted should also have an ANOVA method applied to the number of samples selected for tests and the number of measurements taken during experimentation in order to maximize the statistical confidence of the work.

With the limited number of tests conducted and the single set up established, reproducibility and robustness of the experiment was not addressed. Robustness and reproducibility would provide confidence in the data collected during this work. Conducting reproducibility and robustness tests with radioactive samples would likely expose lab personnel to unnecessary levels of radiation, but could likely be accomplished using non-active samples.

APPENDIX A

TEST PROCEDURES

1. Passive Current Density Test Procedures
    1.1. Passive Current Density Apparatus Test Procedures
    1.2. Passive Current Density Electrode Construction

2. Irradiation Procedures
    2.1. Corrosion and Thermal Sample Irradiation
    2.2. Wire Irradiation Procedure
    2.3. General Irradiation Requirements

3. Thermal Conductivity Test Procedures
4. Weight Gain Test Procedures
5. Sample Preparation, Handling And Storage
    5.1. Sample Preparation
        5.1.1. Passive Current Density Sample Preparation
        5.1.2. Thermal Conduction Sample Preparation
        5.1.3. Weight Gain Sample Preparation
        5.1.4. Electrical Wire Resistance Sample Preparation

A.1 Passive Current Density

Section A.1 includes the procedures used to construct and then test Aluminum 2024 T3 panels with four different corrosion resistant treatments. In order to establish repeatability and uncertainly levels, there could be no less than five electrodes generated for each Aluminum coating to be examined (Alodine, Type III, Type II, and native oxide) at each of the four fluence levels from Appendix A.2. This means there was a minimum of 80 electrodes built per this section.

The panels to be used in electrode construction were prepared per the instructions in Appendix A.5 and irradiated per the instructions in Appendix A.2. As a result, 60 of the eighty electrodes were radio-active. There was special consideration for the protection of the environment, and precautions were taken to facilitate the safety of lab personnel. For safety details see Appendix A.6 and for preparation, handling and storage see Appendix A.5.
The basic concept behind the passive current density test is to determine the rate of surface dissolution of the panels by measuring the current generated in the test apparatus. The test was refined prior to the firm establishment of these procedures. Several different sweep rates and current converter settings were explored, along with different salt concentrations in the solution.

Electrode assembly was also an iterative process requiring the construction of nearly 30 test articles. Questions regarding the polishing of the panel surfaces were explored too. Ultimately it was observed that the panels with a polishing step provided less reliable data than the unpolished, finished surfaces generated at HAFB on the anodize process lines. The settings and assembly instructions prescribed below were determined to generate the most reliable data for this test setup.

A.1.1 Passive Current Density Apparatus Test Procedures

1. Record all the steps and observations during the testing phase in the test log book.
2. Set up the testing apparatus.
    a. Pine Instrument company RTD3 (U of U inventory control #204341) linked to a PC, to generate and record the data.
    b. EMI shield enclosure.
    c. AL working electrode (sample electrode).
    d. Ag-AgCl reference electrode.
    e. Pt counting electrode.
    f. Salt Water solution (0.1-0.2 M).
3. Set the voltage range from -1.4 volts to 1.4 volts.
4. Set the voltage sweep rate to 0.1 volts/second.
5. Set the offset voltage to zero.
6. Set the current converter to 20 mA.
7. Connect the sample electrode to the K1 port and place it in the salt water solution with the working electrode and reference electrode.

    Note: CE is the counting electrode port and Reff is the Ag-AgCl electrode
8. Verify there are no air bubbles present on the Working or Counting electrodes and that the air bubble is at the top of the Reff electrode.
9. Verify none of the electrodes are in direct contact with one another.
10. Place solution in the EMI shield enclosure and verify the door is closed.
11. Start data collection.
12. Examine data for signs of sample electrode defect (erratic data, or drastic deference from other samples and literature values).

13. If the data indicates no setup anomalies record no less than one full sweep and copy the data to the testers thumb drive for future analysis.

A.1.2 Passive Current Density Electrode Construction

1. Prepare AL 2024 T3 samples for each of the four oxide treatments and each of the four fluence levels per the instructions in Appendix A.5.
2. Cut 80 glass tubes not to exceed 0.25 inches in diameter to lengths of approximately 4 inches.
3. Cut 80 sections of coated silver wire approximately 6 inches in length.
    a. Wire gauge only needs to be sufficient to provide mechanical stability and fit in the glass tubing.
    b. If the wire being used has an insulating coating, strip the two ends of the wire of about ½ inch of the coating.
4. Place the wire through the glass tube.
5. Using a sharp cutting tool remove protective oxide coating from a section of one side of the panel being prepared as an electrode. (note: this helps facilitate the passage of current to the face of the electrode during the testing stage)
6. Place one end of the stripped wire from the wire glass tube assembled in step three on the section of panel that the protective oxide layer was removed from and fix it in place using a silver epoxy.
    a. Step 5 must be completed less than 60 seconds after completing step 4.
    b. Allow time for the silver epoxy to dry.

   c. The mechanical strength of the assembly at this point is very weak; precautions must be taken for careful handling to not break the established connection prior to completion of step 6.

7. Using regular epoxy (electrical insulator) "glue" the assembly together at the joint where the glass tube meets the panel and the wire comes in contact with the panel.
   a. Allow time for the epoxy to dry.
8. Using insulating epoxy coat the entire panel across the back (where the wire contacts the panel) and along the edges.
9. Keeping the center of the front of the panel clear of epoxy, use a toothpick to apply the epoxy to adjust the surface area that will be exposed to the solution during testing.
   a. Allow time for the epoxy to dry
10. Examine the electrode assembly for defects paying special note to areas not sufficiently covered by the final epoxy coat.
    a. In the event that the coating is not sufficient re-apply the coat and then re-examine.

       Note 1: It is critical the edges of the panel are properly covered; the edges must be carefully examined.

       Note 2: It is critical the insulating epoxy coat seals the wire away from the solution and seals the inside of the glass tube from the solution; the joint should be carefully examined.
11. Test the electrodes for leakage.
    a. Create a small puddle of saline solution

b. Place the electrode with the back of the panel down in the puddle being careful to not allow the open front face of the electrode to come into contact with the saline solution.

c. Test continuity

   i. If the electrode acts as an insulator it passes

   ii. If the electrode acts as a conductor it fails

d. Place each edge of the electrode in the saline puddle being careful to not allow the open front face of the electrode to come into contact with the saline solution.

e. Test each edge per step c

f. If the electrode passes the leak test on the back of the panel and each edge rise in de-ionized (DI) water carefully dab the test surface dry and store the panel for later testing.

12. Within 30 minutes of testing the article (PCD electrode) per section 1.1, clean the open front face of the electrode.

    a. Rinse in Propanol for 30 seconds in the Type 3PN1010 set at about ½ of max vibration.

    b. Rinse in Ethanol for 30 seconds in the Type 3PN1010 set at about ½ of max vibration.

    c. Rinse in DI water for 30 seconds in the Type 3PN1010 set at about ½ of max vibration.

A.2 Irradiation Procedures

Generic start-up and shut down irradiation requirements and procedures are contained in UNEP procedures along with documentation requirements. This section focuses on the irradiations requirements specific to the series of tests contained in this test report.

In an attempt to maximize reactor time both the Fast Neutron Irradiation Facility (FNIF) and the Center Irradiator (CI) were used. The samples were broken into four separate packets. Control-no irradiation, Pac 1-highest fluence bombardment Pac 2- mid level fluence bombardment and Pac 3 lowest fluence bombardment.

All steps requiring the handling of irradiated samples must be done in accordance with the directions prescribed in Appendix A.5.

A.2.1 Corrosion and Thermal Sample Irradiation

Assemble the samples designated to receive the highest fluence bombardment, be sure each sample packet is marked Pac 1 and encapsulated in a polyurethane cover.

1. Assemble the samples designated to receive the mid fluence bombardment, be sure each sample packet is marked Pac 2 and encapsulated in a polyurethane cover.
2. Assemble the samples designated to receive the lowest fluence bombardment, be sure each sample packet is marked Pac 3 and encapsulated in a polyurethane cover.
3. Place sample packets marked Pac 1 in the bottom of the center cavity of the non in situ measurement enabled CI.
4. Place sample packets marked Pac 2 above the Pac 1 samples in the center cavity of the non in situ measurement enabled CI.
5. Assemble the bottom and the top of the CI.

6. Place the sample packets marked Pac 3 in the FNIF at the high fluence point per the UNEP FNIF flux map.
7. Place the CI in position one in the TRIGA reactor Core.
8. Following UNEP reactor start up procedures bring the reactor power 90 kW and bombard the sample until the tank water temperature reaches 32^0C.
9. Shut the reactor down
10. Remove the CI and suspend it in the tank at least 10 feet below the water surface making sure there is no increase in radiation in the reactor room.
11. Wait one week and pull the CI to the top of the tank while continuously measuring the activity.
    a. If the activity is within NRC and UNEP established limits remove the sample, if not re-suspend for another week.
12. [GCP] Take the CI to the radio chem lab and disassemble.

    Note: for steps 13-16 continuous radiation monitoring is required.
13. [GCP] Remove the Pac 2 samples from CI and store in accordance with Appendix 1 section 5.3.2.
14. [GCP] Reassemble the CI and place it back in the reactor tank.
15. Survey all items which came in contact with the sample or the CI. Mitigate contamination if necessary according to UNEP lab procedures.
16. Place CI in position one in the TRIGA reactor core.
17. Place FNIF in the slot adjacent to the TRIGA reactor core.
18. Following UNEP reactor start up procedures bring the reactor power 90 kW and bombard the samples until the tank water temperature reaches 32^0C.
19. Shut the reactor down per the UNEP lab procedures.

20. Remove the CI and the FNIF and suspend in the reactor tank at least 10 feet below the surface.
21. Wait one week and pull the FNIF to the top of the tank while continuously measuring the activity.
    a. If the activity is within NRC and UNEP established limits remove the samples, if not re-suspend for another week.
22. [GCP] Remove the Pac 3 samples from the FNIF and store in accordance with Appendix 1 section 5.3.2.
23. Place CI in position one in the TRIGA reactor core.
24. Following UNEP reactor start up procedures bring the reactor power 90 kW and bombard the samples until the tank water temperature reaches 32^{0}C.
25. Shut the reactor down per the UNEP lab procedures.
26. Remove the CI and suspend in the reactor tank at least 10 feet below the surface.
27. Wait one week and pull the CI to the top of the tank while continuously measuring the activity.
    a. If the activity is within NRC and UNEP established limits remove the samples, if not re-suspend for another week.
28. [GCP] Take the CI to the radio chem lab and disassemble.
29. [GCP] Remove the Pac 1 samples from CI and store in accordance with Appendix A.5.3.2.
30. [GCP] Reassemble the CI and place it back in the reactor tank.
31. Survey all items which came in contact with the sample or the CI. Mitigate contamination if necessary according to UNEP lab procedures.

A.2.2 Wire Irradiation Procedure

1. Place the CI facility prepared in Appendix A.7 in the position one of the TRIGA reactor core.
2. Following UNEP reactor start up procedures bring the reactor power 90 kW and bombard the sample until the tank water temperature reaches 32^0C.
3. Following the UNEP reactor shut down procedures shut the reactor down.
4. Remove the CI and suspend in the tank at least 10 feet below the surface of the water.
5. Wait one week and repeat steps one through five for each additional bombardment.
6. Wait one week after the final bombardment and pull the CI to the top of the tank while continuously measuring the activity.
    a. If the activity is within NRC and UNEP established limits remove the samples, if not re-suspend for another week.
7. Place assembly in storage in accordance with Appendix A.5.3.2.

A.2.3 General Irradiation Requirements

- Irradiation requests must be made one week prior to scheduled operation, and must include details of time, material, purpose, expected outcomes of the test, and criticality calculations when necessary.
- All requests are approved by the UNEP director and the reactor supervisor.
- All runs must be recorded in the Reactor log book per license agreement.
- Never at any time will these samples be inserted in the core after startup

- Never at any time will samples be removed from the core until the reactor is completely shut down.
    - Removal of the CI would result in a criticality jump and in turn a power spike.
- Never at any time will the reactor be operated without two persons present with the appropriate licensing.
- Preliminary Neutron Activation Analysis will be conducted to more fully characterize Aluminum 2024 and the decay properties of the lot used in this series of tests.

A.3 Thermal Conductivity Test Procedures

The thermal conductivity tests procedures identified in this section were used to collect data on four Aluminum 2024 T3 samples. Each one of these samples corresponds to one of the four fluence levels identified in Appendix A.2. The four samples were cut per the procedures in Appendix A.5 and had a basic rectangular prism shape.

The basic concept behind this test was to measure each rectangular prism prior to irradiation and again after to determine the extent of neutron damage induced thermal conductivity change. The design idea was to have the test article insulated on all sides except one which would be placed against an ice block. The temperature at each end of the article would then be measured in time so a temperature profile could be generated and a thermal conductivity calculated.

Because this was an attempt to measure the thermal properties of the AL 2024 T3 and the alumina is a thermal insulator compared to the metal underneath, the coating was considered to be irrelevant and all four samples were cut from the Type III sample with the Type III coating appearing only two of the six side. Neither coated side was used as a thermal couple interface, or for the ice contact.

Several different configurations were explored for this test (tape, insulation, test article dimension); the procedures below yielded the most reliable data.

Note : GCP designates a glove critical procedure. All the steps marked with GCP must be done wearing a clean pair of latex glove and special attention must be paid to not contaminate the glove by touching any items not necessary to accomplish the procedure.

1. Obtain four rectangular prism test articles approximately 2 ¾ cm in height, 0.4 cm in width and ½ to ¾ cm in length (see Appendix A.5)
2. Record the dimensions and weight for each of the four articles using the caliper (Batten product item number 672060, be sure to zero the tool, accuracy is to within 0.01 mm) and the DI U of U ICN 212842 scale located in the UNEP radio chemistry lab (accuracy is to within .0001 g)
3. As needed, form a Styrofoam insulating shell with at least 2 ^{2}2 of insulating material in all directions from the center with a center cavity large enough to hold the test articles, one at a time. Do not allow more than ½ cm of void space between the insulation and the text article center cavity sides with the exception of one side (length/width surface) which will have all insulating material removed creating a hole from the shell surface to the center cavity.

4. As needed, install the software to operate the TempBook/66 Thermocouple/voltage measurement system on the PC which will be used to record temperature and time.
5. As needed, Connect TempBook/66 Thermocouple/voltage measurement system to the PC.
6. As needed, Connect K-type thermal couples to the Omega TempBook/66 Thermocouple/voltage measurement system on ports 0 and 1.
7. Place a k-type thermal couple at each end of the text article and fix in place using a narrow strip of duct tape ~1.5 cm long and ~0.3 cm wide.
8. Place the test article in the Styrofoam insulating shell, and close the shell in order to insulate the article.
9. Align the test article in the center cavity so that one surface (length/width) is flush with the outer surface of the insulating shell.
10. Allow the test article to reach thermal equilibrium (no less than 5 minutes).
11. In the software, set all the channels off except for 0 and 1.
12. Set Pole to B.
13. Set units to ^{0}C.
14. Set sequence Rep rate to 1/sec.
15. Set the number of scans to 10.
16. Check the averaging option.
17. Set the signal referencing to differential.
18. Obtain a small block of ice and flatten the top surface.
19. Start data collection and bring the insulated shell with the test article in contact with the flat side of the ice block being sure that the exposed surface of the text

article is in the approximate center of the ice surface, and maintain contact until the collection is complete.

20. Verify charts are good and store data for future analysis.
21. Remove test article from insulating shell.
22. Repeat steps 7 through 21 for each of the test articles.
23. [GCP] Carefully clean each article in DI water using an initial liquid soap coat followed by generous amount of water to completely rinse all soap residue and foreign material off the test article surfaces. (This step is critical to remove salt and oils deposited and any residues left on the surface during bare hand contact, article fabrication, and initial thermal tests)
24. [GCP] Form a containment packet from clean polyurethane of sufficient size to completely encapsulate the test article.
25. [GCP] Place the test article in the packet and heat seal the packet.
26. [GCP] As necessary store the test article in accordance with Appendix A.5.
27. [GCP] As necessary retrieve test article and irradiated the samples in accordance with Appendix A.2.
28. Post irradiation, when the test articles are safe to handle (see Appendix A.6) retrieve the articles and conduct steps 7 through 21 for each of the samples.
    a. Note: these samples are radioactive, follow mitigating actions per Appendix A.6.
    b. Note: Because of the activity, one good data collection will be sufficient for obtaining results from each sample.

A.4 Weight Gain Test Procedures

The weight gain test was established to examine the diffusion of oxygen through the oxide layer. The concept was to explore the diffusion effects of fluence and coating types on an Al 2024 T3 panel by measuring the weight gains. Each panel was placed in a DI water bath; the water simulated a reactor tank environment with clean water. The samples were irradiated to see what the weight gain difference would be as a function of fluence and coating. In order to have a statistical population for measure there were no less than five panels created and tested for each of the fluence levels and coating types.

Note : GCP designates a glove critical procedure. All the steps marked with GCP must be done wearing a clean pair of latex glove and special attention must be paid to not contaminate the glove by touching any items not necessary to accomplish the procedure.

1. Prepare weight gain AL 2024 T3 samples for each of the four oxide treatments and each of the four fluence levels per Appendix A.5.
2. Using a toothpick and non-conductive epoxy, coat the edges of every panel such that only clean unmarred surface is exposed on either side of the panel.
    a. Use a rubber coated clamp to hold the panel while the epoxy dries. Allow 24 hours for epoxy to dry.
    b. Inspect the faces of the panel for visible defects such as gouges, marks, discoloration, and scratches, if defects exists coat that side with epoxy, if both sides have defects reject the panel.
3. [GCP] Carefully clean both sides of each panel in DI water using an initial liquid soap coat followed by generous amount of water to completely rinse all soap residue and foreign material off the test article surfaces. (This step is critical to

remove salt and oils deposited and any residues left on the surface during bare hand contact, and article fabrication)

a. Do not scrub the panels.
b. Gently dry the panels by dabbing the surfaces dry, and allow 24 hours of air dry time for complete drying.

4. [GCP] Record the exposed oxide surface dimensions and weight for each of the panels using the caliper (Batten product item number 672060, be sure to zero the tool, accuracy is to within 0.01 mm) and the DI U of U ICN 212842 scale located in the UNEP radio chemistry lab (accuracy is to within .0001 g).
5. [GCP] Form a containment packet from clean polyurethane of sufficient size to completely encapsulate each test article groupings.
   a. The groupings consist of:

      i. Type III *ii.* Type II *iii.* Alodine *iv.* Natural Oxide

      for each of the four fluence levels described in Appendix A.2, therefore sixteen separate packets will be prepared.
6. [GCP] Place the test articles in the packets according to grouping and heat seal the packets.
7. [GCP] Mark each packet according to its contents.
8. [GCP] As necessary store the test article in accordance with Appendix A.5.
9. [GCP] As necessary retrieve test article and irradiated the samples in accordance with Appendix A.2.
10. [GCP] Postirradiation, when the test articles are safe to handle (see Appendix A.6) retrieve the articles and place in an air dry environment for 1 week to allow for complete drying.

11. Be sure to maintain traceability of each article to the appropriate packet.
12. Examine the articles and record visual observations of the samples.
13. Inspect each article for protective epoxy layer failures.
    a. Reject any article with epoxy that failed during the irradiation process.
14. Record the weight for each of the panels using the DI U of U ICN 212842 scale located in the UNEP radio chemistry lab (accuracy is to within .0001 g)
    a. Note: these samples are radioactive; follow mitigating actions per Appendix A.6.
15. Store test items in accordance with Appendix A.5.

A.5 Sample Preparation, Handling and Storage

Section A.5 contains instructions which when specified, apply to individual tests or test articles. In this section there are also general instructions which apply to all the tests at all times unless otherwise instructed in the sections specific to the test articles.

A.5.1 Sample Preparation

A.5.1.1 Passive Current Density (PCD) Sample Preparation

1. Obtain four panels prepared with aluminum oxide coats (three each) Type III, Type II, Alodine, and Native Oxide.
2. Select one panel of each type from which all the PCD samples will be cut.
3. Inspect the panels for defects and mark any defects present.
    a. Areas with defects will be discarded when all the cut are made.
4. Using any available cutting tool, cut the panels into smaller samples ~ (½) inch x (½) inch

5. Cut no less than forty samples from each panel
    a. Defect and damage attrition demands over production to mitigate the risk of losing the final required sample population.
6. Inspect every sample for defects on the surfaces (scratches, gouges, mars, etc.) and reject samples with defects.
7. Store the samples in per Appendix A.5.3

A.5.1.2 Thermal Conduction Sample Preparation

1. Obtain one panel prepared with aluminum oxide coat Type III.
2. All the thermal conductivity samples will be cut from the single panel.
    a. Surface defects are not relevant for this test.
3. Using any available cutting tool (band saw), cut from the panel, four rectangular prism test articles approximately 2 ¾ cm in height, 0.4 cm in width and ½ to ¾ cm in length
4. Verify the test articles width and length dimensions do not deviate more than 20% along the height.
5. Wipe the oil and debris from the cut off the test article.
6. Store the samples in per Appendix A.5.3.

A.5.1.3 Weight Gain Sample Preparation

1. Obtain four panels prepared with aluminum oxide coats (three each) Type III, Type II, Alodine, and Native Oxide.
2. Select one panel of each type from which all the PCD samples will be cut.
3. Inspect the panels for defects and mark any defects present.

   a. Areas with defects will be discarded when all the cut are made.

4. Using any available cutting tool, cut the panels into smaller samples ~ (½) inch x (½) inch

   (Dimensions are critical when measured but only need to fit in the center cavity of the center irradiator)

5. Cut no less than forty samples from each panel
   a. Defect and damage attrition demands over production to mitigate the risk of losing the final required sample population.

6. Inspect every sample for defects on the surfaces (scratches, gouges, mars, etc.) and reject samples with defects.

A.5.1.4 Electrical Wire Resistance Sample Preparation

1. Obtain bare 99% aluminum wire with a diameter of 0.001 inches.
   a. Wire is extremely delicate-handle carefully
2. Cut six wire lengths to between 6 and 9 feet.
3. Lay the wire flat on a nonconductive surface and test resistance using alligator clamps and a multimeter then record the results.
   a. The clamps are to create consistent contact pressure resistance.
4. Hang the wire vertically so the wire is suspended from the ground.
5. [GCP] Coat the wire with a liquid insulating rubber leaving four to six inches at each end exposed.
   a. Apply coating thinly because the weight of the rubber can break the wire.
   b. Allow the rubber to dry.

6. Place the wire in a conductive bath with the exposed ends clear of the solution and using the same multi-meter and alligator clamps from step 3 test the conductivity of the wire.
    a. A change of more than 3% is likely an electrical leak in the wire. If this is the case remove the wire, allow time to dry and reapply rubber coat per steps 4 and 5.
    b. If the wires conductivity has not changed or has changed less than 3% the sample is acceptable.

A.5.2 Fluence Level Description

Four fluence levels were tested as a function of this work. The levels proposed were zero (control), 10^{15} n/m^2, 10^{16} n/m^2, and 10^{17} n/m^2. The levels achieved were zero, 3.07×10^{15} n/m^2, 1.04×10^{17} n/m^2, and 3.07×10^{17} n/m^2. These levels were achieved over the course of several reactors runs from 20-May-11 to 10-Jun-11 in the UNEP TRIGA reactor (see section 3 methods for reactor description). The two higher fluencies were achieved in the center irradiator facility which has a modeled average neutron energy of 580 KeV while the lower fluence level was achieved in the Fast Neutron Irradiation Facility, FNIF which has an average neutron energy of 2 MeV (see Appendix C).

A.5.3 Sample Storage

A.5.3.1 Preradiation Storage

Proper storage of all the samples prepared for this test is critical. Prior to irradiation the samples are safe for the experimenter to handle and these items can be stored in a manner that will protect the test surfaces and structure of each article. Test integrity was maintained by clearly marking all storage areas with labels identifying the test articles and when feasible marking the articles themselves. To protect the article test surfaces from damage and contamination these general instructions will apply unless otherwise instructed in the sections specific to the test articles.

- Never allowing the test articles to sit on top of one another.
- Keeping the samples between two chem wipes to protect the surfaces at all times.
- Post cleaning; never handling the articles or their reactor containment packets without clean gloves on.
- Keeping the samples in a drawer or protected area which precluded inadvertent contact with any lab activities.

A.5.3.2 Postradiation Storage

Post radiation storage while critical for test quality is twice as vital due to the safety elements involved with radioactive samples. All the elements of section 5.3.1 apply to postradiation storage with the additional requirements.

- Build a shielded storage area using lead.
- Test the area for radiation leaks.
- Store all samples that have been irradiated in the lead shielded area.
- Monitor radiation levels in the immediate before and after sample handling to verify the shield has not be compromised in any way.

A.5.4 Sample Handling

Test article specific instructions are contained in the A.5.4 subsections below. In addition to the specific instructions provided in other sections, these general instructions will also apply unless otherwise instructed in the sections specific to the test articles.

- All the samples will be subject to postradiation handling instructions.
- Samples which are subjected to radiation bombardment will be cleaned with soap and DI water prior to insertion into the reactor.
- Containment vials, packets and facilities will be clean prior to insertion into the reactor.
- Post cleaning, items that will be inserted into the reactor will only be handled wearing clean gloves.
- All samples will have traceability during preparation and testing in order to establish data integrity.
- Samples will be stored or discarded when the experiment is complete in accordance with UNEP protocols and established NRC requirements.

A.5.4.1 PCD Corrosion and Weight Gain Samples

Surface defects can greatly affect and distort data when examining corrosion properties. Care must be taken in order to not introduce defects into the samples being used to test corrosion and diffusion. At all times when handling these samples take care to not touch the surface of the sample unless directed to do so in the procedure. The following are actions necessary to protect the samples surfaces:

- Samples should not be slid across any surface.

- Sample surfaces should not be rubbed or scrubbed during cleaning.
- Samples will be handled on the edges unless otherwise directed by the procedure.
- Samples will be given a quick visual inspection prior to any test on it.
- Nonabrasive interfaces will be used to insulate samples from abrasive surfaces (tables, scale plates, etc.).

A.5.4.2 Wire Samples

The wire samples, due to the small diameter, are extremely fragile. Due to the extremely fragility of the samples, washing the wire prior to inserting the samples in the reactor is not feasible. In order to minimize the potential contamination associated with the wire and maintain the structural integrity of the sample the following actions are necessary:

- Handle the wire as little as possible.
- When handling the wire, only touch the ends unless directed otherwise in a specific procedure.
- When applying the rubber coating wear clean gloves.
- Keep the samples separated.
- Keep the ends of the samples separated.
- Make resistance test connections at the very ends of the wire.
- Breathe away from and move slowly around the bare wire (air currents are enough to break the wire).
- Do not allow the wire to bend at the end of the rubber coat.

- The rubber provides a little bit of mechanical support but creates a high probability break point right at the location along the wire where the coating is no longer present.

A.5.4.3 Thermal Conductivity Samples

The thermal conductivity samples consist of a type III anodized rectangular prism. They are fairly solid and the surface coat is not critical to the test. Beyond section 5.4.4 there are no special considerations given to the samples during handling. Section 5.4 and 5.4.4 apply to these samples.

A.5.4.4 Post Irradiation Handling of Samples

In order to maintain the integrity of the tests being performed, all the sample handing instructions in section 5.4 through 5.4.3 remain in effect for postradiation handling. In addition to those sample handling instructions, postradiation handling instructions for samples will apply too, and are embedded in testing, preparation, setup, and test article construction in several cases. Whenever working with a sample that has been irradiated the following instructions apply:

- Transportation of samples will be accomplished using a portable lead shield unless speed will be reduced such that more exposure will occur with the shield than without.
- When feasible all samples preparation and tests will be conducted behind a lead shield.

- Time of exposure will be limited to the lowest time possible to accomplish needed tasks.
- Dosimeters will be worn at all times while in the lab (pre and post irradiation)
- A finger dosimeter will be worn in addition to the regularly worn dosimeter required during daily operations in the UNEP facility.
- Minimization of radiation exposure is a higher priority than collection of additional data for confidence measurements.
- Whenever feasible, tools such as soft tipped tweezers will be used to increase the distance of the samples from the experimenter's digits.
- Experimenter will maximize distance from test articles as much as possible during all stages of work.
- Gloves will be worn anytime samples are being handled.
- Handheld radiation monitors will be used during all stages of work to allow the experimenter to gauge distance requirements and personal risk.
- At the completion of any actions handling the samples, a radiation survey will be conducted on all items used to accomplish the action [scales, meters, calipers, gloves, experimenter, thermal couples, chem wipes, etc.] to ensure the safety of the public, lab personnel and the cleanliness of the action.
    - Any contamination of any item must be handled in accordance with UNEP facility protocols.
- Only trained personnel are allowed to handle radioactive samples or be in the facility when samples are being handled.

A.6 Safety/Risks

The purpose of the safety section is to identify the risks associated with the testing and how those risks were mitigated. The four categories of risk effects are:

1. Catastrophic $1 million or death
2. Critical $200,000-$1 million or partial/permanent disability
3. Marginal $10,000-$200,000 or 1 loss day of work
4. Negligible $2,000-$10,000 or loss of work hours

On a scale of one to four with four being very low risk the analysis for this test shows overall personnel safety is a three (medium), while overall risk to equipment is four (low) and the overall risks to the test is a two (serious). Tests, and sample preparation, required iterative refinement in order to successfully collect data. Some tests failed completely and were not able to collect the desired data with accuracy or resolution and were excluded from the test report results.

The Mitigation strategy for removing test risk was to refine test methods and sample preparation until results could be achieved, or to acquire the data via another test method. During the development of the test plan several different test methods were explored for corrosion measurements, oxide layer thickening, electrical property changes and thermal property changes. The strategy was effective, for example the Bulk resistivity measurements failed to yield useful data the wire resistance measurements proved effective. Additional discussions of results are found in section 4 of the report.

A.6.1 Personnel Safety/Risks

Risk to personnel is driven by the radiation hazard and the fabrication of test articles and is listed below:

- Exposure of personnel to radiation.
  - Removal of samples from reactor tank
      - Effect-Catastrophic
      - Probability-Negligible (less than 10^{-6})
    - Mitigation-Only trained personnel are allowed to work with the reactor, two person support concept, also See procedures in Appendix A.2
  - Handling and storage of samples post irradiation
      - Effect-Critical
      - Probability-Remote (10^{-3}-10^{-6})
    - Mitigation-Only trained personnel are allowed to handle radioactive samples, sample custody is carefully guarded, sample storage is marked with appropriate symbols, also see procedures in Appendix A.5
- Personnel receive cuts, gouges, digit impalement.
  - Construction of PCD electrodes
      - Effect-Negligible
      - Probability-Occasional (10^{-2}-10^{-3})
    - Mitigation-None
  - Fabrication of test articles from the original panel
      - Effect-Negligible
      - Probability-Occasional (10^{-2}-10^{-3})
    - Mitigation-None

A.6.2 Equipment Safety/Risks

The risk to the equipment was driven by the creation of two new irradiation facilities that fit in position one of the TRIGA reactor Core and by the potential for contamination of lab equipment.

- Rupture of the CI center cavity from thermal pressure
    - Effect-Negligible
    - Probability- Negligible (less than 10^{-6})
  - Mitigation-See section Appendix C CI design
- Alteration of the criticality from inserting or removing experiments from the TRIGA reactor core
    - Effect-Marginal
    - Probability- Negligible (less than 10^{-6})
  - Mitigation-Never remove the CI while the reactor is operating, only trained personnel are allowed to work with the reactor, also, see section Appendix C CI design
- Unanticipated radioactive contamination of lab equipment
    - Effect-Negligible
    - Probability-Occasional (10^{-2}-10^{-3})
  - Mitigation-See section 5.4.4

A.6.3 Test Risks

The risks to the experiment are issues that could reduce the quality of the data reported or undermine the legitimacy of the test. These risks could drive additional analysis or result in lost or repeated work to accomplish the objectives of the test.

- Test articles fail to meet quality inspections
    - Effect-Marginal
    - Probability-Frequent (10^{-1})
        - Mitigation-Production of more test articles than tests call for
- Test configuration fails to meet accuracy requirements
    - Effect-Marginal
    - Probability-Probable (10^{-1}-10^{-2})
        - Mitigation-Redundant tests or redesign of test configuration (i.e. sample prep different test or test setup)
- Test configuration fails to meet resolution requirements
    - Effect-Marginal
    - Probability- Probable (10^{-1}-10^{-2})
        - Mitigation- Redundant tests or redesign of test configuration (i.e. sample prep different test tool or test setup)
- Tests yield unexpected results
    - Effect-Marginal
    - Probability- Probable (10^{-1}-10^{-2})
        - Mitigation-None

A.7 Electrical Resistance Test Procedures

Due to the limited capabilities of available tools to measure bulk resistivity the idea to test a small diameter wire in situ was devised as a replacement test. The diameter of the wire and the resistance per foot are inversely proportional to one other. As a result, smaller diameters result in larger resistances which are easier to measure but, unfortunately, mechanically more difficult to work with.

With higher resistances to measure, smaller percentages of change would also be easier to measure. With 0.001 inch diameter wire lengths ~feet, the models described in Appendix E predicted the changes would be easy to measure.

Note: All the steps in this section must adhere to the handling requirements in Appendix A.5.4.2; also, all the procedures in this section are [GCP]

1. Take one of the bare ends of the wire samples prepared in Appendix A.5.1.4 and wrap it around one of the bare copper leads protruding from the lower end of the top section of the in situ measurement enabled CI as many times possible. In the same manner wrap the other end of the sample around the other copper lead.
2. Place one wrap of electrical tape around the sample lead junction, making sure to have the rubber coated section of the sample under the tape wrapping.
3. Check the resistance of the assembly at the far end of the copper wires leading into the CI using a multimeter and alligator clamps.
    a. Resistance should change but not be more than twice as much as the resistance of the sample.
4. Assemble the top half and the bottom half of the CI.
5. Check the resistance of the assembly at the far end of the copper wires leading into the CI using a multimeter and alligator clamps.
    a. Use the same meter for step three and five, resistance should be within 0.1% of the value measured in step three

6. Following all the applicable steps in Appendix A. 2 place the CI in position one in the TRIGA reactor core.
7. Measure the resistance of the assembly in the reactor core using alligator clamps and a multimeter, leave the multimeter attached for the duration of the test.
    a. Resistance should be within 0.1% of the values measured in step three and five.
8. While bringing the reactor to power and during the reactor run at regular interval not to exceed 10 minutes, record time, resistance, temperature, and power.
9. Following reactor shut down, measure time, resistance, and temperature twice in the first hour the sample is out of the core and then ~daily until the next neutron bombardment.
10. Follow steps six through nine for each additional bombardment.

APPENDIX B

DATA

1. Passive Current Density Data

    1.1. Control

        1.1.1. Alodine Control

        1.1.2. Anodize Type II Control

        1.1.3. Anodize Type III Control

        1.1.4. Natural Oxide Control

    1.2. Pac 1

        1.2.1. Pac 1 Alodine

        1.2.2. Pac 1 Anodize Type II

        1.2.3. Pac 1 Anodize Type III

        1.2.4. Pac 1 Natural Oxide

    1.3. Pac 2

        1.3.1. Pac 2 Alodine

        1.3.2. Pac 2 Anodize Type II

        1.3.3. Pac 2 Anodize Type III

        1.3.4. Pac 2 Natural Oxide

    1.4. Pac 3

1.4.1. Pac 3 Alodine

1.4.2. Pac 3 Anodize Type II

1.4.3. Pac 3 Anodize Type III

1.4.4. Pac 3 Natural Oxide

1.5. Passive Current Density Electrode Area

2. Thermal Conductivity Data

2.1. Pac 1

2.1.1. Thermal Conductivity Pac 1 Preirradiation

2.1.2. Thermal Conductivity Pac 1 Postirradiation

2.2. Pac 2

2.2.1. Thermal Conductivity Pac 2 Preirradiation

2.2.2. Thermal Conductivity Pac 2 Postirradiation

2.3. Pac 3

2.3.1. Thermal Conductivity Pac 3 Preirradiation

2.3.2. Thermal Conductivity Pac 3 Postirradiation

3. Weight Gain Measurements

3.1. Weight Gain Measurements

3.2. Weight Gain Area Measurements

4. Flux Map Data

4.1. CI Flux Map Data

5. Run Data

6. Wire Resistance Data

B.1 Passive Current Density Data

B1.1 Control

B.1.1.1-Alodine Control

Alodine Control 1		Alodine Control 2		Alodine Control 3		Alodine Control 4		Alodine Control 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-0.13119	625.7748	-0.21901	625.1501	-0.73013	11.90916	-1.31367	-110.946	-0.6319	59.41048
-0.07912	766.3081	-0.16689	844.1225	-0.78206	-20.645	-1.26144	-79.5644	-0.6842	29.73503
-0.02677	930.7596	-0.11465	1096.918	-0.83455	-54.281	-1.20892	-50.8936	-0.73653	-0.57153
0.025105	1091.122	-0.06236	1342.906	-0.88692	-97.841	-1.15692	-33.2738	-0.78876	-35.238
0.076942	1248.167	-0.01019	1584.991	-0.93914	-154.126	-1.10474	-13.3163	-0.84114	-80.4917
0.128993	1421.158	0.041794	1844.246	-0.99126	-217.045	-1.05256	-10.9463	-0.89323	-139.688
0.181107	1582.802	0.093979	2109.766	-1.04334	-286.861	-1.00045	-8.88554	-0.94561	-205.698
0.233737	1757.763	0.146164	2371.906	-1.09586	-350.353	-0.94838	0.272113	-0.99745	-282.778
0.285854	1923.696	0.198211	2656.586	-1.14811	-403.206	-0.89592	2.519667	-1.04982	-357.128
0.338064	2085.861	0.25042	2948.143	-1.20005	-444.692	-0.84367	8.186852	-1.10208	-424.303
0.389894	2231.257	0.302283	3231.155	-1.25229	-464.334	-0.79152	3.987983	-1.15447	-480.621
0.441837	2397.286	0.354428	3500.327	-1.30463	-487.363	-0.73947	10.32493	-1.20652	-529.661
0.494356	2541.02	0.4066	3777.51	-1.3571	-498.453	-0.68717	8.322092	-1.25888	-572.886
0.546334	2697.666	0.458913	4049.606	-1.37484	-446.238	-0.63495	6.267737	-1.31101	-590.828
0.598475	2815.531	0.511113	4291.589	-1.32446	-337.338	-0.58315	14.4272	-1.3633	-614.405
0.650649	2953.791	0.56288	4582.477	-1.27232	-249.612	-0.53085	14.83291	-1.37068	-557.482
0.702906	3111.139	0.615373	4829.914	-1.22013	-189.327	-0.47853	17.30587	-1.31843	-431.851
0.754966	3292.386	0.667516	5086.007	-1.16806	-137.737	-0.42631	30.94575	-1.26656	-333.261
0.806952	3448.414	0.719306	5298.585	-1.11588	-94.3892	-0.37434	89.17608	-1.21425	-256.271
0.859043	3611.114	0.771377	5607.93	-1.06344	-57.8037	-0.32196	194.2573	-1.16209	-190.635
0.910972	3763.561	0.823878	5904.517	-1.01146	-33.9435	-0.27027	321.1893	-1.10973	-132.243
0.963672	3877.736	0.87573	6157.866	-0.95941	-12.1506	-0.2178	475.1436	-1.05771	-93.9384
1.015368	4033.687	0.927615	6391.02	-0.9071	1.701789	-0.16561	652.1852	-1.00542	-53.2055
1.067471	4195.814	0.979867	6654.77	-0.85489	10.60829	-0.11336	845.4749	-0.953	-26.5697
1.119728	4332.882	1.032173	6911.629	-0.80282	17.78243	-0.06138	1065.458	-0.90111	-7.54603
1.171705	4486.701	1.084201	7120.922	-0.75061	20.68686	-0.00927	1283.342	-0.84898	4.013743
1.224036	4653.439	1.136274	7383.59	-0.69822	25.51685	0.042649	1501.948	-0.79679	17.87903
1.275971	4795.003	1.188467	7670.814	-0.64631	29.57404	0.094897	1711.157	-0.74458	25.21417
1.328115	4928.581	1.240737	7968.348	-0.59387	28.57584	0.147045	1933.858	-0.69252	33.55394
1.379384	5105.514	1.292841	8227.204	-0.54202	27.56476	0.199031	2162.722	-0.6401	33.63766
1.365699	5095.287	1.344936	8505.611	-0.48966	30.91355	0.251341	2411.879	-0.58801	38.76389
1.313513	4965.734	1.385821	8752.167	-0.43737	51.4571	0.303269	2663.573	-0.53591	42.99496

1.261109	4846.626	1.348901	8602.005	-0.38522	119.3088	0.355303	2907.584	-0.48364	44.07044
1.208893	4731.904	1.296625	8416.752	-0.33327	270.3586	0.407448	3171.205	-0.43132	61.63227
1.156368	4584.074	1.244378	8184.12	-0.28111	466.3466	0.459675	3373.401	-0.37939	128.7433
1.104083	4447.031	1.192065	7920.892	-0.22872	692.01	0.511851	3566.124	-0.32728	252.7452
1.052073	4296.219	1.139561	7681.678	-0.17706	952.4494	0.563971	3753.779	-0.27487	397.9024
0.999587	4226.416	1.087387	7423.653	-0.12486	1236.607	0.616019	3919.796	-0.22297	555.2827
0.947408	4083.358	1.035141	7213.156	-0.07262	1543.634	0.668158	4170.472	-0.17111	733.915
0.894707	3959.942	0.982733	6950.436	-0.02041	1847.517	0.72044	4349.349	-0.11866	948.9396
0.842675	3908.268	0.93076	6734.336	0.031537	2154.028	0.772396	4546.316	-0.06652	1191.965
0.790263	3746.979	0.878099	6518.319	0.083754	2452.541	0.824639	4722.94	-0.01436	1432.544
0.738013	3605.75	0.826078	6281.218	0.135774	2743.216	0.876556	4944.437	0.037602	1665.819
0.685753	3418.159	0.773523	6076.078	0.187878	3058.724	0.929008	5083.045	0.089807	1911.576
0.633322	3255.775	0.721137	5818.942	0.239882	3367.676	0.980823	5268.941	0.141798	2127.644
0.581564	3139.018	0.669095	5564.633	0.29211	3661.694	1.033231	5451.309	0.193956	2385.713
0.529057	3013.496	0.616814	5361.355	0.344266	3944.892	1.085146	5687.058	0.246197	2619.871
0.476929	2861.332	0.564619	5127.815	0.396451	4249.098	1.137294	5895.649	0.298351	2900.127
0.424587	2723.323	0.512132	4881.344	0.44865	4508.546	1.189485	5956.507	0.350362	3152.909
0.372144	2579.402	0.460118	4635.214	0.500818	4764.49	1.241755	6251.909	0.402394	3417.464
0.32013	2456.502	0.408044	4391.589	0.552875	5054.985	1.293495	6452.399	0.454585	3651.158
0.267728	2330.922	0.355387	4160.355	0.604982	5338.706	1.345745	6595.238	0.506899	3868.243
0.215587	2200.441	0.303374	3941.254	0.657071	5630.991	1.385849	6704.338	0.558933	4099.355
0.163221	2051.246	0.251191	3759.916	0.709233	5854.601	1.347735	6636.905	0.611051	4306.234
0.111105	1931.99	0.198917	3554.661	0.761514	6119.812	1.295425	6564.249	0.663239	4508.011
0.058636	1787.026	0.146465	3310.946	0.813688	6411.055	1.242909	6366.232	0.715122	4728.343
0.006682	1653.609	0.094175	3095.696	0.865566	6645.96	1.190724	6142.455	0.767188	4987.282
-0.04567	1525.305	0.041963	2857.925	0.917756	6901.866	1.138352	6081.095	0.819602	5218.233
-0.09786	1393.447	-0.00993	2630.942	0.970024	7195.375	1.086156	5953.145	0.871734	5473.888
-0.15008	1247.774	-0.06246	2391.947	1.022079	7508.7	1.033737	5864.241	0.923614	5680.888
-0.20224	1115.349	-0.11452	2152.141	1.074116	7697.36	0.981519	5742.377	0.97589	5884.418
-0.25475	972.4778	-0.16685	1911.981	1.126167	7964.722	0.929295	5562.682	1.027753	6070.572
-0.30686	835.2675	-0.21906	1684.077	1.178462	8213.467	0.877253	5351.154	1.080099	6320.386
-0.35902	692.8472	-0.27133	1452.63	1.230643	8482.459	0.824549	5218.246	1.132327	6569.968
-0.41137	547.6771	-0.32351	1214.1	1.282643	8729.594	0.772393	5072.393	1.184448	6891.414
-0.46339	402.1721	-0.37557	978.6151	1.334775	9037.549	0.720052	4923.668	1.236468	7052.832
-0.51569	268.7872	-0.42785	757.0668	1.383233	9243.667	0.668022	4749.743	1.289006	7269.312
-0.56781	144.341	-0.48034	531.8348	1.359424	9121.191	0.61571	4550.554	1.340743	7426.712
-0.62007	63.9571	-0.53269	327.0948	1.306995	8976.427	0.563454	4346.052	1.385211	7570.273
-0.67254	21.89758	-0.58468	160.4474	1.254455	8840.047	0.511175	4176.468	1.35309	7495.73
-0.72487	1.225231	-0.63694	65.8569	1.202326	8665.529	0.459029	3937.46	1.30074	7317.554
-0.77721	-28.6241	-0.68937	29.04596	1.149779	8475.15	0.406648	3794.351	1.248467	7188.903
-0.82911	-70.0911	-0.74131	-7.87447	1.097516	8304.117	0.354348	3615.216	1.195989	7011.088

-0.88135	-116.614	-0.79349	-59.858	1.045227	8031.344	0.302112	3447.03	1.143654	6882.005
-0.93355	-167.2	-0.84613	-129.12	0.993055	7816.68	0.249919	3260.006	1.091418	6675.59
-0.98591	-225.366	-0.89821	-200.868	0.940774	7681.369	0.197483	3096.817	1.039002	6590.795
-1.03805	-291.427	-0.9503	-296.901	0.888355	7472.784	0.145307	2943.5	0.986734	6387.239
-1.0902	-344.615	-1.00271	-386.314	0.836259	7240.558	0.092913	2759.786	0.934612	6191.766
-1.1426	-398.859	-1.05504	-475.256	0.783987	7003.27	0.040664	2554.46	0.882191	5957.769
-1.19479	-441.279	-1.1072	-554.738	0.73159	6742.36	-0.01131	2349.862	0.829903	5761.027
-1.24679	-473.176	-1.15927	-626.325	0.679358	6508.711	-0.06363	2165.189	0.777756	5553.454
-1.29913	-486.178	-1.21129	-689.663	0.627082	6261.853	-0.11582	1932.544	0.725476	5370.287
-1.35167	-506.516	-1.26393	-735.509	0.57492	6011.82	-0.16796	1728.699	0.67317	5150.51
-1.37767	-483.261	-1.31604	-770.182	0.52244	5776.683	-0.22017	1518.936	0.620984	4925.812
-1.33037	-380.369	-1.36815	-797.165	0.47028	5563.307	-0.27262	1297.433	0.568618	4706.402
-1.27827	-301.164	-1.36602	-709.768	0.418205	5327.7	-0.32475	1094.11	0.516313	4530.371
-1.22554	-238.413	-1.31353	-556.181	0.365666	5069.868	-0.37713	888.1462	0.464153	4320.788
-1.17346	-184.336	-1.2615	-439.868	0.313251	4808.772	-0.42921	680.5469	0.41169	4194.352
-1.12147	-137.209	-1.20909	-333.564	0.261338	4520.801	-0.48145	476.4831	0.35949	3978.445
-1.06907	-99.348	-1.15705	-248.498	0.208866	4271.419	-0.53388	281.899	0.307156	3757.881
-1.01699	-68.2235	-1.10502	-182.024	0.156477	3985.896	-0.58619	125.2722	0.25525	3537.144
-0.96498	-40.3255	-1.05242	-117.644	0.104405	3699.149	-0.63822	46.89115	0.202641	3321.102
-0.91264	-18.0947	-1.00027	-70.2586	0.052177	3427.71	-0.6904	22.97305	0.15062	3110.521
-0.86031	-4.37756	-0.94819	-36.6805	-3.1E-05	3153.405	-0.74271	9.423328	0.098346	2878.791
-0.80818	11.56784	-0.89626	-4.64803	-0.05205	2871.462	-0.79489	-25.4943	0.046081	2660.945
-0.75615	21.58202	-0.84364	12.45012	-0.10427	2586.19	-0.84698	-57.1146	-0.00614	2451.279
-0.70375	20.17166	-0.79162	29.32288	-0.15668	2306.179	-0.89946	-101.338	-0.05841	2257.358
-0.65181	32.74251	-0.73978	38.73169	-0.20885	2028.996	-0.95182	-158.789	-0.11053	2027.489
-0.59942	33.98542	-0.68751	43.54236	-0.26135	1761.035	-1.00374	-215.519	-0.16276	1811.756
-0.54743	40.07765	-0.63519	54.62557	-0.31327	1487.966	-1.05602	-278.392	-0.21506	1583.851
-0.49523	43.08512	-0.58314	55.88781	-0.36572	1206.372	-1.10852	-335.74	-0.26734	1374.371
-0.44305	49.93726	-0.53097	58.40584	-0.4178	937.0128	-1.16061	-381.818	-0.31955	1158.973
-0.39088	83.28993	-0.47861	67.37673	-0.47008	670.1399	-1.21283	-413.516	-0.3717	942.6671
-0.33895	149.757	-0.42639	92.66011	-0.52227	413.9509	-1.26518	-430.943	-0.42391	722.4003
-0.28666	243.9224	-0.3743	162.3085	-0.57448	207.0342	-1.31738	-441.73	-0.47609	509.9002
-0.23495	351.1095	-0.32212	292.1901	-0.62664	89.36284	-1.36952	-434.375	-0.52846	319.3668
-0.18248	480.0122	-0.27002	449.2613	-0.67889	43.3878	-1.36431	-358.113	-0.58079	160.3057
-0.13042	627.3397	-0.21813	637.3797	-0.73123	9.764647	-1.31201	-257.636	-0.63293	67.57637
-0.07801	789.55	-0.166	849.3388	-0.78353	-36.2555	-1.25971	-184.761	-0.68508	33.50886
-0.02579	954.4845	-0.11377	1071.551	-0.8357	-91.8454	-1.20768	-130.517	-0.73723	0.246353
0.025992	1107.904	-0.06158	1319.503	-0.88791	-164.836	-1.15535	-91.7746	-0.78972	-47.7637
				-0.94004	-245.51	-1.10324	-62.2472		
						-0.9986	-18.4747		
						-0.9466	-0.65525		

						-0.8944	6.280617		
						-0.8422	13.15208		
						-0.79013	14.71699		

B.1.1.2-Anodize Type II Control

Anodize Type II Control 1		Anodize Type II Control 2		Anodize Type II Control 3		Anodize Type II Control 4		Anodize Type II Control 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-0.2621	677.507	-0.3409	-2.3812	-0.5092	-1.1576	-1.2138	-1.1447	-1.2664	-1.9046
-0.3143	562.412	-0.2888	0.80663	-0.4571	0.42023	-1.2661	-1.6212	-1.3186	-0.417
-0.3667	449.397	-0.2368	-3.0767	-0.4048	0.14331	-1.3183	-3.0058	-1.3705	-4.5064
-0.419	341.456	-0.1845	-4.223	-0.3528	0.93543	-1.3704	-0.9257	-1.3631	0.18839
-0.4711	243.04	-0.1322	-1.7758	-0.3006	2.06243	-1.3635	-2.3039	-1.3109	-0.8871
-0.5234	156.48	-0.0801	-2.2266	-0.2485	-0.0563	-1.3113	1.20591	-1.2587	-0.0499
-0.5756	84.3074	-0.0283	-0.4298	-0.1965	2.71287	-1.2587	-0.9579	-1.2062	-0.462
-0.6278	50.6392	0.02394	0.24635	-0.1441	10.3442	-1.2067	-2.832	-1.154	3.87206
-0.6802	29.7994	0.07616	-0.5393	-0.092	10.5825	-1.1546	-3.3407	-1.1019	-1.003
-0.7323	5.19226	0.12834	0.16263	-0.0399	10.8144	-1.1021	-0.0692	-1.0497	-2.3296
-0.7847	-27.078	0.18045	-0.2173	0.01225	7.04697	-1.0502	3.33111	-0.9975	-1.5053
-0.8367	-70.342	0.23263	3.69818	0.06421	19.5277	-0.998	-2.0978	-0.9454	-1.4087
-0.8892	-113.31	0.28483	-0.5522	0.11634	17.8597	-0.9458	0.06603	-0.8932	1.60519
-0.9414	-177.75	0.33688	2.48747	0.16875	26.8113	-0.8934	-1.6792	-0.841	-2.2202
-0.9937	-241.18	0.38882	-0.7325	0.22074	27.0045	-0.8415	-3.5854	-0.7889	-2.394
-1.0458	-312.94	0.44106	-1.0094	0.27296	29.1619	-0.7891	-2.0785	-0.7369	0.07247
-1.0982	-389.72	0.49299	0.54903	0.32488	38.3453	-0.737	-1.6534	-0.6845	0.97407
-1.1501	-463.85	0.54529	-1.4538	0.37708	39.659	-0.6849	-0.4878	-0.6322	1.68247
-1.2026	-533.89	0.59738	-1.0288	0.42926	52.1719	-0.6325	-0.6746	-0.5801	0.56835
-1.2546	-593.04	0.64951	0.87103	0.48158	56.725	-0.5805	-2.2652	-0.528	-2.1944
-1.3067	-649.93	0.70189	-2.5035	0.53353	59.5264	-0.5282	-2.2008	-0.4756	-1.4023
-1.3592	-698.03	0.75399	-3.3021	0.58568	58.4316	-0.4762	1.90143	-0.4237	-1.0288
-1.3737	-669.62	0.80591	-2.4906	0.63771	64.5947	-0.424	-1.9304	-0.3715	-4.0749
-1.3228	-561.45	0.85812	-1.0481	0.68993	73.147	-0.3719	1.48927	-0.3191	2.55831
-1.2706	-459.23	0.91043	-1.9239	0.74211	83.2191	-0.3197	-0.8098	-0.2672	-5.0731
-1.2182	-364.73	0.96233	-1.0223	0.79429	77.1397	-0.2675	-0.7068	-0.2149	-0.2688
-1.1663	-285.21	1.01444	-3.6563	0.84649	84.6423	-0.2154	-1.2348	-0.1629	-0.0306
-1.1138	-212.68	1.06674	-0.7583	0.89857	90.799	-0.1633	0.60055	-0.111	2.87387
-1.0613	-154.27	1.11879	1.26387	0.95067	91.2691	-0.1111	-1.7307	-0.0588	-1.5762
-1.0095	-104.15	1.17096	-0.2173	1.00286	93.9288	-0.059	-2.0205	-0.0064	-2.027

-0.9573	-58.267	1.22308	1.86279	1.05476	107.524	-0.0068	-3.5597	0.04571	2.06887
-0.9053	-26.067	1.27503	0.02095	1.10681	105.115	0.04506	0.08535	0.09793	-3.3021
-0.8528	0.91611	1.32738	-2.9608	1.1591	112.476	0.09722	-0.417	0.14998	-2.6323
-0.8008	22.2711	1.37869	-0.3332	1.21136	111.993	0.14943	-1.1511	0.20216	0.39447
-0.7483	31.9246	1.36749	0.89679	1.26345	117.718	0.20174	-4.648	0.25433	-1.7243
-0.6963	40.4898	1.31508	-1.2992	1.31559	129.851	0.25384	-2.993	0.30626	-1.2026
-0.6445	48.0117	1.26261	-0.1594	1.36753	132.652	0.30591	1.16727	0.35845	-4.7833
-0.5922	51.5408	1.21045	-0.6102	1.3785	143.774	0.35786	-2.0592	0.41046	2.04311
-0.5398	59.9386	1.15809	0.43311	1.32684	130.16	0.41036	2.54543	0.46269	-3.7658
-0.4877	67.0547	1.10579	-4.4226	1.27457	129.96	0.46224	0.41379	0.51498	-1.0738
-0.4356	84.8162	1.05335	-0.8549	1.22218	132.099	0.51444	-1.5697	0.56705	-1.2348
-0.3834	114.305	1.00114	-2.027	1.16989	121.312	0.56657	0.72291	0.61915	-2.2395
-0.3312	171.138	0.94885	-2.1558	1.11758	117.312	0.6185	-2.6581	0.67143	-1.0932
-0.2792	253.846	0.89678	-2.6645	1.06535	115.644	0.67085	-2.5872	0.72343	0.75511
-0.2271	345.333	0.84433	-2.1815	1.01299	115.432	0.72295	-3.8237	0.77546	-1.1382
-0.175	441.83	0.79204	-2.0334	0.96079	106.532	0.77531	4.70282	0.82784	-0.8678
-0.1226	553.029	0.7399	-1.1125	0.90832	108.129	0.82727	0.27855	0.87986	1.67603
-0.0706	671.363	0.6874	-3.9268	0.8562	94.1155	0.87952	-4.7318	0.93186	-1.0867
-0.0184	790.039	0.63524	-1.5182	0.80374	96.1248	0.93158	-2.7933	0.98404	-0.3268
0.03366	910.499	0.58283	0.18195	0.75135	90.9664	0.98393	-1.8917	1.03613	2.57763
0.08565	1033.39	0.53062	-3.3085	0.69932	87.257	1.03584	3.07351	1.08809	-0.8549
0.13781	1137.48	0.47851	-2.4198	0.647	84.5908	1.08783	-3.8495	1.14048	-1.5182
0.18997	1244.27	0.42618	-3.6627	0.59473	83.1483	1.13993	-0.3848	1.19254	-0.7518
0.24228	1355.55	0.37378	-0.6681	0.54239	76.6503	1.19207	3.47922	1.24467	-2.0334
0.29415	1457.74	0.3217	-1.8144	0.49018	74.0614	1.24412	-1.4023	1.2968	-2.0463
0.34641	1557.38	0.26927	1.41843	0.43781	69.444	1.29638	-2.3747	1.34883	-1.5375
0.39859	1664.59	0.21696	-3.6176	0.38562	65.2709	1.34852	-1.0288	1.3863	-3.5082
0.45056	1759.01	0.16496	-3.2634	0.33334	62.1475	1.38657	-0.2109	1.34537	-1.8982
0.50276	1859.5	0.11264	-0.4363	0.28105	57.0792	1.34585	-4.2745	1.29315	0.87103
0.55495	1950.35	0.0604	1.75975	0.22889	62.785	1.29361	-0.4234	1.24076	-2.3103
0.60698	2041.72	0.00806	-2.0141	0.17648	55.3597	1.24142	-1.3508	1.18852	-1.0223
0.65923	2138.54	-0.0441	-1.9883	0.12426	50.7165	1.18901	2.06887	1.13615	-0.1272
0.71129	2232.33	-0.0963	-1.0996	0.0719	47.3548	1.13668	2.29427	1.08376	-3.2184
0.76351	2321.69	-0.1485	-1.1769	0.01985	44.9205	1.08465	1.79839	1.03152	-5.1246
0.81552	2424.17	-0.2011	0.71003	-0.0324	39.2469	1.03237	-0.198	0.97918	-1.8402
0.86777	2534.05	-0.2534	-1.428	-0.0847	39.0279	0.97953	-0.7776	0.92691	0.77443
0.91956	2621.15	-0.3053	1.08355	-0.1369	35.3829	0.92741	-0.1529	0.87489	0.01451
0.97184	2715.72	-0.3577	1.16083	-0.1892	32.7683	0.87526	-6.8247	0.82241	-0.3397
1.02399	2815.61	-0.4099	-2.2266	-0.2413	25.8131	0.82296	-2.7933	0.77024	1.48927
1.07603	2901.68	-0.4621	-1.7758	-0.2935	19.547	0.77051	-1.6341	0.71778	-1.5118
1.12813	2986.75	-0.5145	-1.5311	-0.3459	17.2093	0.71836	-3.2184	0.66564	-4.2488

1.18048	3110.27	-0.5667	-0.9644	-0.3983	12.0444	0.66605	-2.7998	0.61314	-1.5568
1.23245	3214.37	-0.6188	-6.2709	-0.4505	7.22729	0.61386	-1.1511	0.56095	-4.12
1.2847	3309.3	-0.6711	-3.6305	-0.5029	5.88134	0.56163	-1.5633	0.50878	0.43955
1.33659	3403.83	-0.7235	-1.7372	-0.5547	1.86923	0.5094	-1.1318	0.45643	-3.8881
1.38406	3508.9	-0.7758	-2.5486	-0.6072	1.35403	0.45702	0.02739	0.40414	-0.3397
1.35724	3506.79	-0.8278	-0.301	-0.6594	-0.0756	0.4049	-1.6792	0.3518	-2.13
1.30489	3421.4	-0.8799	-2.935	-0.7117	-3.4116	0.35225	2.38443	0.29958	-2.716
1.25253	3333.59	-0.9322	-3.9525	-0.7638	-3.2248	0.30028	-2.394	0.24732	-5.8394
1.2001	3236.49	-0.9846	-2.1107	-0.8162	-4.9056	0.24775	0.99983	0.19508	-2.1944
1.14787	3127.95	-1.0368	-0.3526	-0.8684	-4.4162	0.19572	-1.3121	0.14269	-1.5955
1.09577	3024.83	-1.089	-0.7712	-0.9205	-3.5597	0.14342	-3.0767	0.09048	1.77907
1.04312	2919.15	-1.1413	-0.7261	-0.9729	-5.2083	0.09104	5.30174	0.03832	-0.3461
0.99083	2806.13	-1.1935	-1.7629	-1.0253	-7.7263	0.03902	0.00807	-0.0141	-3.9718
0.9387	2740.14	-1.2459	-1.8788	-1.0774	-12.08	-0.0132	1.61163	-0.0662	1.09643
0.88644	2672.34	-1.2982	-2.2846	-1.1295	-12.692	-0.0655	0.49107	-0.1182	-1.7887
0.83423	2574.37	-1.3503	1.99159	-1.1817	-11.468	-0.1178	-0.8549	-0.1704	-2.0076
0.78182	2479.79	-1.3784	-1.325	-1.2342	-13.522	-0.1702	1.16083	-0.2226	-1.6019
0.72958	2417.66	-1.3314	-2.4069	-1.2862	-15.635	-0.2221	-2.1493	-0.2753	-0.4492
0.6773	2342.57	-1.2792	0.05959	-1.3384	-19.363	-0.2744	-2.5937	-0.3272	2.44883
0.62497	2346.17	-1.2269	-1.2155	-1.3799	-14.682	-0.327	-1.7694	-0.3797	1.92719
0.57281	2248.04	-1.1746	-1.222	-1.3435	-9.7678	-0.379	-4.0878	-0.4317	-3.0896
0.52051	2143.81	-1.1225	1.36691	-1.2913	-10.174	-0.4312	-1.589	-0.484	-0.9322
0.46815	2041.99	-1.0704	2.49391	-1.2387	-9.2913	-0.4835	-1.0481	-0.5362	-4.2681
0.41589	1954.73	-1.0182	-4.0234	-1.1868	-2.8577	-0.5356	-2.3296	-0.5883	-2.3876
0.36372	1842.17	-0.9659	0.27211	-1.1344	-4.1779	-0.5881	-0.4105	-0.6406	1.41843
0.31144	1728.65	-0.914	-2.7225	-1.0821	-1.5697	-0.6402	-0.681	-0.693	0.05315
0.25916	1626.47	-0.8614	-0.3912	-1.0298	0.02095	-0.6925	-0.8935	-0.7453	0.13043
0.20681	1521.81	-0.8095	-2.5808	-0.978	-1.8144	-0.7448	1.36047	-0.7974	-0.9837
0.15476	1427.33	-0.7571	-0.0177	-0.9256	-3.1604	-0.7969	-0.5522	-0.8499	-3.8881
0.10247	1338.29	-0.7052	-0.7905	-0.8736	-0.6874	-0.8491	-2.1236	-0.9023	-2.0656
0.05032	1236.62	-0.6529	-3.7078	-0.8211	1.91431	-0.9015	-0.6681	-0.9542	-0.6424
-0.0019	1134.54	-0.6008	0.20771	-0.7693	-0.1658	-0.9537	0.14331	-1.0065	0.48463
-0.0541	1022.1	-0.5486	-0.3397	-0.7171	-1.6084	-1.0061	0.45243	-1.0589	1.68891
-0.1064	915.046	-0.4963	-2.832	-0.6648	1.07067	-1.0582	0.05315	-1.1109	1.78551
-0.1584	812.341	-0.4442	1.30251	-0.6126	0.69071	-1.1103	-3.7078	-1.1633	2.13327
-0.211	709.185	-0.3923	-0.417	-0.5603	-3.2248	-1.1626	1.11575	-1.2153	-1.1576
-0.2633	602.72	-0.3399	1.39267	-0.5083	-2.7869	-1.2148	-5.2276	-1.2678	-1.6921
-0.3154	499.796	-0.2879	-0.2882	-0.4562	1.18015	-1.2669	-1.6534	-1.32	-1.4474
-0.3677	401.567	-0.2357	-0.462	-0.4037	2.25563	-1.3194	-3.2699	-1.3715	2.98335
-0.42	305.122	-0.1835	-0.301	-0.3518	2.62271	-1.3711	1.08355	-1.3618	-1.1962
-0.4723	218.459	-0.1313	-2.5164	-0.2998	2.61627	-1.3628	0.07247	-1.3095	-2.072

		-0.0793	-3.1153	-0.2475	4.85738	-1.3104	1.66959	-1.2573	-1.6277
		-0.0272	-1.4731	-0.1956	7.53641	-1.2579	1.41199	-1.205	-0.4041
		0.02497	-1.7243			-1.2061	1.92075	-1.1526	-0.3397
		0.07723	0.09179			-1.1541	-0.3783	-1.1006	0.12399
		0.12922	-2.7096			-1.1016	-1.3958	-1.0482	-4.0105
		0.18147	-6.0004			-1.0491	-1.1769	-0.9962	-2.0914
		0.23351	-2.1815			-0.9971	0.50395	-0.9438	0.02739
		0.28555	-2.4842			-0.945	-0.1465	-0.8919	-1.325
		0.33773	-0.7068			-0.8928	0.72291	-0.8397	-5.3951
		0.39006	-2.8899			-0.8406	-1.3186	-0.7875	-3.1926
		0.44192	-1.9432			-0.7882	2.26851	-0.7351	1.28963
		0.49408	-1.061			-0.7363	-1.7565	-0.6831	-0.7068
		0.5463	0.72935			-0.6842	-1.9432	-0.6309	-2.3232
		0.59847	0.47819			-0.6318	-2.2459	-0.5788	-0.6295
		0.65065	2.04311			-0.5796	-0.0692	-0.5267	2.35223
		0.70263	-0.2817			-0.5273	-2.1815	-0.4746	-1.9626
		0.75487	-4.281			-0.4754	-1.5504	-0.4223	2.46815
		0.80689	-0.3204			-0.4233	0.04027	-0.37	-2.832
		0.85921	-5.5046			-0.3713	-3.2055	-0.318	-2.0076
		0.91116	0.57479			-0.3189	-4.1715	-0.2659	-2.5615
		0.96323	-2.2266			-0.2668	-0.4814	-0.2137	-1.7758
		1.0154	-1.2026			-0.2145	-2.7225	-0.1616	-2.4262
		1.06765	0.30431			-0.1624	0.12399	-0.1095	-1.5246
		1.11963	-2.2202			-0.1103	2.41663	-0.0571	-1.6599
		1.1719	-5.2534			-0.0582	-1.6985	-0.0053	-0.4105
		1.22414	-0.4556			-0.006	1.24455	0.04691	-2.0463
		1.27629	0.35583			0.046	0.02739	0.09901	-1.1447
		1.32828	-2.5293			0.09831	0.23347	0.15144	-1.4216
		1.37916	1.52791			0.15011	0.38159	0.20332	-2.5422
		1.36641	-0.3526			0.20234	1.13507	0.25558	0.55547
		1.31404	1.03847			0.25473	-1.267	0.30768	1.29607
		1.26186	-2.7676			0.30659	-1.4087	0.35981	-1.3894
		1.20945	1.86923			0.35875	0.58123	0.41193	0.28499
		1.15712	-0.6939			0.41098	1.76619	0.46401	-2.0012
		1.10474	-1.7436			0.46327	-1.3636	0.51627	1.11575
		1.05234	-1.7178			0.5153	1.72111	0.56834	0.56835
		1.00022	-2.0978			0.56754	-0.9	0.62032	-2.8255
		0.94778	-1.7307			0.61944	-0.9515	0.67271	-1.9432
		0.8956	1.84347			0.67158	-1.1189	0.72461	1.41843
		0.84339	-3.257			0.72372	1.72755	0.77694	-0.1336
		0.79087	-5.5883			0.77611	0.40735	0.82885	0.11755

		0.73868	-0.417			0.82818	-1.5118	0.88129	-2.0334
		0.68642	0.18839			0.88017	-2.6516	0.93321	-0.9837
		0.63424	2.65491			0.93238	-0.095	0.98536	0.23347
		0.58179	0.97407			0.98451	-1.5118	1.03758	-1.2091
		0.52965	-0.359			1.03651	-1.7372	1.08952	-5.6849
		0.47731	0.27211			1.08876	-1.544	1.14165	-0.7712
		0.42498	-2.0398			1.14085	1.35403	1.19381	-1.8209
		0.3728	-3.9718			1.19301	2.88675	1.24594	-1.9948
		0.32057	-2.2524			1.24521	1.43775	1.29819	2.13971
		0.26829	-1.5826			1.29746	-1.4989	1.35009	-0.784
		0.21601	-2.7869			1.34943	-5.8201	1.38628	-2.0656
		0.16376	-2.3683			1.38627	-3.8237	1.3444	-1.3701
		0.11142	-1.9368			1.34504	-1.4409	1.29181	1.06423
		0.05933	1.27675			1.29269	-2.6581	1.23961	-0.52
		0.00712	-3.418			1.24019	0.56191	1.18747	-5.1053
		-0.0455	-1.3057			1.18806	-2.9608	1.13501	-1.8209
		-0.0974	-1.911			1.13585	0.82595	1.08282	0.29143
		-0.1495	-1.4087			1.08347	0.75511	1.03029	1.44419
		-0.2018	-1.9368			1.03101	1.14795	0.97811	-3.5726
		-0.254	-1.6212			0.97867	1.66315	0.92587	-2.5228
		-0.3064	-0.945			0.92639	-3.476	0.87348	-0.4942
		-0.3587	-1.6985			0.87431	-7.6619	0.82116	-2.5293
		-0.411	1.07067			0.82182	-4.9121	0.76891	0.09179
		-0.4631	-0.14			0.7695	-1.647	0.71661	-0.7776
		-0.5153	0.87103			0.71733	-3.1604	0.66446	1.87567
		-0.5676	-1.0416			0.66534	1.94007	0.61204	-1.2864
		-0.6198	-0.578			0.61282	-4.6931	0.55995	1.77263
		-0.6723	-2.1364			0.56041	-2.613	0.50759	-3.4566
		-0.7243	-0.681			0.50815	-4.5643	0.45536	-0.8356
		-0.7767	-0.3719			0.45613	-2.4456	0.40312	0.00807
		-0.8288	-0.784			0.40378	0.78731	0.35091	2.26207
		-0.8811	-0.3912			0.35142	-0.6746	0.2984	0.27211
		-0.9332	-3.4888			0.29927	-0.9386	0.2463	-0.784
		-0.9856	-0.5136			0.2468	-3.2763	0.19397	1.42487
		-1.0379	-2.0849			0.1947	-3.1089	0.14172	1.79839
		-1.09	-1.8144			0.14228	-1.8788	0.08955	-2.1429
		-1.1423	-0.6488			0.09015	0.42667	0.03731	-3.0123
		-1.1946	-1.8209			0.03789	-0.037	-0.015	2.13327
		-1.2468	-1.6792			-0.0142	0.12399	-0.0672	-2.0334
		-1.299	-2.5937			-0.0664	-5.0344	-0.1194	-1.7822
		-1.3513	0.25923			-0.1187	-2.671	-0.1717	-1.1833

		-1.3779	-4.9185			-0.1708	-2.0463	-0.2238	-0.8742
		-1.3305	-2.188			-0.2232	-3.418	-0.2764	2.80303
		-1.2781	-0.6102			-0.2755	-4.0105	-0.3284	-0.3139
		-1.2258	-3.0767			-0.3276	1.81771	-0.3806	0.22059
		-1.174	0.57479			-0.3799	-2.4971	-0.4328	-2.5872
		-1.1216	-1.7629			-0.4323	-1.5504	-0.485	-2.5486
		-1.0693	-0.3848			-0.4842	-2.51	-0.5374	-0.5844
		-1.0173	-0.7132			-0.5369	-3.9139	-0.5896	-0.8678
		-0.9649	-2.1042			-0.5889	1.83703	-0.6419	-3.3085
		-0.9127	-3.2055			-0.6413	-2.4649	-0.694	-1.4731
		-0.8607	1.34759			-0.6935	-3.1346	-0.7463	-4.6802
		-0.8085	-0.8806			-0.7458	-1.5504	-0.7986	-2.4778
		-0.7563	-0.1078			-0.7979	-2.5035	-0.8509	-4.8863
		-0.7042	-2.5615			-0.8503	-2.9865	-0.9031	-0.5458
		-0.6519	1.25743			-0.9024	0.00163	-0.9554	-0.9837
		-0.5999	-3.3858			-0.9546	0.16263	-1.0076	-1.8853
		-0.5476	0.43955			-1.0069	-3.1218	-1.0596	0.97407
		-0.4955	-2.1107			-1.0592	0.12399	-1.1123	-0.2366
		-0.4433	-2.1042			-1.1113	0.63275	-1.1643	-2.3425
		-0.3912	0.42667			-1.1636	-0.1336	-1.2166	0.54259
		-0.3391	0.77443			-1.2159	1.34115	-1.2686	-3.476
		-0.2868	-3.9203			-1.2681	-4.1522	-1.3209	2.04955
		-0.2348	0.05315			-1.3201	-2.2137	-1.3724	-0.3075
		-0.1827	-1.1962			-1.3718	-0.4492	-1.3611	0.10467
		-0.1305	-1.911			-1.3615	-4.0298	-1.3086	-1.0352
		-0.0782	-6.097			-1.3095	-1.0738	-1.2565	-0.784
		-0.0262	-1.3121			-1.2572	0.74223	-1.2041	-2.6967
		0.02593	-1.0159			-1.205	1.18659	-1.1518	-2.0914
		0.07807	-0.3204			-1.1528	0.37515	-1.0999	1.12863
		0.13026	-1.6148			-1.1003	-1.4602	-1.0475	-0.2173
		0.18218	-1.4796			-1.0483	1.30895	-0.9955	0.63919
		0.23434	-1.2413					-0.9434	-1.0996
		0.28663	-2.2202					-0.8909	-3.1024
		0.3388	-2.8448						
		0.39092	-2.9092						
		0.44297	-1.911						
		0.49529	-3.4695						
		0.54722	-0.9064						
		0.59947	1.51503						
		0.65144	-1.4216						
		0.70386	-1.0738						

		0.75578	-0.5007						
		0.80793	1.13507						
		0.86	-0.8034						
		0.91234	-2.832						
		0.96427	-3.0509						
		1.01656	-1.8788						
		1.06884	-0.6359						
		1.12077	-1.3636						
		1.17301	-1.7629						
		1.22511	-1.6985						
		1.27716	-1.7372						
		1.32909	-0.8356						
		1.38014	-2.3747						
		1.36527	-1.7436						
		1.31285	-0.9515						
		1.2607	-3.2119						
		1.2084	1.59875						
		1.15626	-1.0094						
		1.10384	-1.5118						
		1.05153	0.51683						
		0.99916	-1.8724						
		0.94703	-2.6194						
		0.89478	-2.0463						
		0.84226	-0.9966						
		0.7899	-5.7493						
		0.73773	-1.1769						
		0.68527	-3.096						
		0.63326	-1.4087						
		0.58098	1.72755						
		0.52866	-0.1722						
		0.47637	-1.911						
		0.42407	-1.4731						
		0.37188	-1.8595						
		0.31968	-1.544						
		0.26745	-0.9386						
		0.21513	-1.0932						
		0.16291	0.38159						
		0.11035	-4.9636						
		0.05831	-4.9572						
		0.00589	-4.7962						
		-0.0462	-1.6921						

		-0.0983	-1.267						
		-0.1506	-0.5007						
		-0.203	0.17551						
		-0.2551	-0.4814						
		-0.3074	-2.5357						
		-0.3598	-1.0416						
		-0.4118	-4.2294						
		-0.4642	1.82415						
		-0.5163	0.31719						
		-0.5689	0.57479						
		-0.6209	-0.8291						
		-0.6732	-1.9046						
		-0.7253	-1.3572						
		-0.7776	-2.7418						
		-0.8299	1.39911						
		-0.882	2.07531						
		-0.9343	-1.4216						
		-0.9866	-0.681						
		-1.0389	-2.7225						
		-1.091	-5.3564						
		-1.1434	-4.0749						
		-1.1955	-1.0159						
		-1.2478	2.86099						
		-1.3001	-2.1107						
		-1.3522	-0.5458						
		-1.3776	-0.9708						
		-1.3296	-0.9644						
		-1.2774	-0.7325						
		-1.225	-0.8935						
		-1.173	-0.1722						
		-1.1207	-3.1862						
		-1.0684	-1.3508						
		-1.0166	-2.51						
		-0.964	0.62631						
		-0.912	0.38159						
		-0.86	-2.4842						
		-0.8077	-1.7372						
		-0.7554	0.90967						
		-0.7032	-1.6148						
		-0.6512	0.48463						
		-0.5988	-0.6681						

		-0.547	-2.0914						
		-0.4946	-4.0878						
		-0.4426	-3.3214						
		-0.3904	-0.3332						
		-0.3382	-1.325						
		-0.2862	2.40375						
		-0.2339	-1.9368						
		-0.1819	-1.4538						
		-0.1296	-1.8982						
		-0.0775	-1.2026						
		-0.0254	-4.1006						
		0.02674	-3.7207						
		0.07898	0.14331						
		0.13098	-2.3425						
		0.18315	0.26567						

B.1.1.3-Anodize Type III Control

Anodize Type III Control 1		Anodize Type III Control 2		Anodize Type III Control 3		Anodize Type III Control 4		Anodize Type III Control 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
1.332828	-1.106043	-0.135182	-3.617636	0.924827	1.875669	-0.750408	-0.429845	-0.064337	68.16885
1.382409	5.533579	-0.083449	2.667788	0.976834	2.667787	-0.698387	-1.634122	-0.116188	57.35612
1.361772	0.342953	-0.030726	-3.199037	1.028912	1.57943	-0.646227	2.912506	-0.168727	48.56554
1.309242	-0.977244	0.021086	6.390098	1.081127	4.947541	-0.594126	-0.320366	-0.22096	28.80124
1.256958	4.393702	0.073199	1.51503	1.13332	2.403747	-0.541871	-2.033401	-0.273155	-14.65577
1.204711	-0.146486	0.125389	-0.880643	1.185428	3.421265	-0.489784	2.294267	-0.32552	-58.69881
1.15214	1.45063	0.177215	0.684272	1.237235	0.967631	-0.437741	-0.648805	-0.377645	-90.56384
1.100204	2.268508	0.229665	-2.18152	1.289703	2.873866	-0.385575	0.413792	-0.429997	-110.7789
1.047715	2.622707	0.281977	-2.458439	1.341587	5.829818	-0.333422	3.717504	-0.482014	-81.43195
0.995643	4.200503	0.333819	0.046714	1.385646	4.612661	-0.281205	3.859183	-0.534304	0.999831
0.942983	2.326468	0.385995	-4.119955	1.352514	3.337545	-0.228868	5.391899	-0.586701	-0.262406
0.890622	3.028426	0.438209	-1.312122	1.29996	1.34115	-0.176947	8.85017	-0.638904	-1.144684
0.838682	-1.717842	0.490199	-4.557874	1.247673	2.493907	-0.124823	8.618331	-0.69124	-4.467715
0.786201	1.115751	0.542283	5.887778	1.195612	0.980511	-0.072678	11.21364	-0.743457	-5.633351
0.734008	-0.957924	0.594525	-4.454834	1.143202	1.927189	-0.020292	10.59541	-0.795639	-8.177145
0.681692	3.060626	0.64666	-0.268845	1.090931	3.504984	0.031359	12.9782	-0.847617	-8.016145
0.629591	-3.263437	0.699163	-2.1622	1.038655	4.979741	0.083773	14.60751	-0.900177	-9.8773

0.576952	-1.737161	0.751022	-0.462045	0.986116	2.262068	0.135969	19.90118	-0.95236	-14.37885
0.524934	-2.889918	0.803086	-1.209083	0.934246	-2.33608	0.188176	17.75667	-1.0046	-18.21708
0.472822	-3.083118	0.855482	-0.796924	0.881579	3.524304	0.24027	20.39706	-1.056851	-20.03959
0.420367	3.691744	0.907305	-2.3876	0.829212	0.104674	0.292213	18.67114	-1.109055	-22.27427
0.367974	3.125025	0.959488	-0.474925	0.77726	0.581232	0.344332	15.20643	-1.161239	-25.39122
0.315869	4.612661	1.011488	-0.030566	0.724591	1.167271	0.396609	17.76311	-1.213514	-24.70214
0.263826	1.682469	1.063818	-0.423405	0.672458	1.733989	0.448746	14.1696	-1.265485	-23.91646
0.211216	-0.243086	1.11606	-0.268845	0.620196	0.909671	0.500757	15.71519	-1.318094	-23.62022
0.159358	1.27675	1.168055	3.144346	0.567927	4.999061	0.552908	14.38212	-1.370043	-24.32862
0.106828	-1.196203	1.220255	-2.542159	0.515677	4.638421	0.605232	8.431571	-1.363963	-15.31909
0.054522	-1.221963	1.272426	0.304313	0.463574	0.864592	0.657339	11.11704	-1.311659	-9.259062
0.002243	1.55367	1.324352	3.659544	0.411033	-0.867764	0.709287	14.234	-1.259381	-8.299504
-0.049833	-0.011246	1.376286	0.259233	0.359002	0.690712	0.761834	10.75641	-1.207169	-4.731754
-0.102173	2.216988	1.370168	-4.493474	0.306438	0.587672	0.813681	10.09309	-1.154765	-4.358235
-0.154324	-3.308517	1.317817	0.284993	0.254358	2.970466	0.865643	11.38108	-1.102491	-0.352566
-0.206911	0.368713	1.265177	-0.513565	0.202197	2.107508	0.918031	8.72137	-1.050421	-0.925724
-0.258809	1.083551	1.212996	0.832392	0.149832	-1.531082	0.970061	11.51632	-0.998168	3.447024
-0.310929	-0.623045	1.160648	4.631982	0.097774	4.348622	1.022153	14.71699	-0.946186	1.18015
-0.363217	0.813071	1.108497	-2.555039	0.04546	6.274177	1.074485	8.309211	-0.893898	-1.067404
-0.415602	0.407353	1.055742	1.837029	-0.006886	0.529712	1.126263	7.967892	-0.841925	0.858151
-0.624689	-1.750042	0.846712	-1.370083	-0.215746	3.453465	1.335086	7.575053	-0.633099	0.162633
-0.676865	-0.829124	0.794638	-4.274515	-0.268262	2.068868	1.383369	8.431571	-0.581005	0.413792
-0.729018	-4.461274	0.742297	0.078914	-0.32023	4.683501	1.359253	8.283451	-0.528934	0.993391
-0.781205	-3.244118	0.690249	-6.476989	-0.372683	0.381593	1.30697	7.864852	-0.476645	0.838831
-0.833581	-5.279152	0.637733	-4.319595	-0.424717	0.954751	1.254604	10.91096	-0.424232	2.699986
-0.885753	-5.639791	0.585425	0.117553	-0.477299	0.645632	1.202407	9.371808	-0.372313	4.406582
-0.938061	-1.550402	0.533178	1.52147	-0.529167	-3.682036	1.149868	7.143574	-0.320337	1.025591
-0.990193	-2.767559	0.481048	-2.08492	-0.58144	1.50215	1.097593	6.931055	-0.26814	8.67629
-1.042703	-3.070238	0.428576	2.777266	-0.633761	-5.098833	1.045306	11.83832	-0.215817	11.175
-1.095097	-1.647002	0.376292	0.523272	-0.686206	-0.906404	0.993187	5.230899	-0.163612	13.21648
-1.147168	-1.550402	0.324068	-2.484199	-0.73847	-0.809804	0.940835	7.433374	-0.111522	15.21287
-1.199126	-1.569722	0.271867	-5.86519	-0.790379	-2.23948	0.888495	9.011169	-0.059301	16.33987
-1.25176	-0.101406	0.219788	-3.971836	-0.842784	-1.144683	0.836141	6.383656	-0.007484	26.27032
-1.303808	-5.221192	0.167467	-3.308517	-0.895017	-6.509189	0.783666	11.05908	0.044801	32.06631
-1.355812	-3.379357	0.115013	1.34115	-0.947205	-5.021553	0.731623	10.04157	0.09684	36.94138
-1.375827	-4.461274	0.062861	-4.319595	-0.999498	-4.068435	0.679374	3.698184	0.148981	68.11089
-1.325655	0.426673	0.010482	-2.941438	-1.051535	-3.089558	0.627122	9.758207	0.201174	85.77577
-1.27328	-2.155761	-0.041434	-3.186158	-1.103942	-1.196203	0.574854	8.096692	0.253306	102.1526
-1.221053	0.523272	-0.093732	0.780872	-1.156323	-0.829124	0.522583	7.072735	0.305549	107.6073
-1.168783	-1.312123	-0.145878	3.524304	-1.208936	-0.648804	0.470243	9.275209	0.357484	95.91874
-1.116608	-0.152926	-0.198449	-2.17508	-1.260809	-1.531082	0.418118	5.308179	0.409537	89.85227

-1.064584	-4.087755	-0.250323	-0.822684	-1.312839	-9.046542	0.365685	6.254857	0.461722	99.98881
-1.012044	-6.921348	-0.302999	-0.030566	-1.365262	0.735792	0.313273	13.69948	0.514077	102.6743
-0.960124	-0.880644	-0.354859	-1.370082	-1.368569	-0.326805	0.26125	10.74997	0.565976	103.4406
-0.908009	0.304313	-0.40748	-1.486002	-1.316463	1.49571	0.208816	10.31205	0.618295	113.3518
-0.855784	-0.500685	-0.459495	3.079946	-1.264287	0.845271	0.156799	9.487728	0.670411	115.0519
-0.803433	1.23811	-0.511867	-5.092393	-1.211991	-1.936801	0.104527	8.025852	0.722585	126.47
-0.751476	-2.928559	-0.563985	2.352227	-1.15979	0.033834	0.052067	12.22472	0.774526	132.3368
-0.699238	-1.936801	-0.616427	-1.537522	-1.107626	-4.010476	0.000062	10.56321	0.826874	135.1576
-0.646856	1.186591	-0.668593	-1.775801	-1.055486	-3.688476	-0.052372	8.161092	0.879153	140.4899
-0.594945	-1.936801	-0.720741	-0.700324	-1.003295	-0.043446	-0.104388	11.26516	0.93135	152.7065
-0.542627	-3.791516	-0.773188	2.500347	-0.951056	3.079946	-0.156821	9.313849	0.983136	158.4381
-0.490705	-4.551434	-0.825204	2.860986	-0.898662	-2.452	-0.209156	9.539248	1.035201	172.7477
-0.438387	-1.672762	-0.877608	-8.067665	-0.846855	-7.951745	-0.261228	10.09309	1.087366	177.9062
-0.385971	-4.693114	-0.929674	-3.450197	-0.794689	-1.595482	-0.313287	8.225491	1.139661	190.2967
-0.333998	0.497512	-0.982155	3.730384	-0.742456	-0.101406	-0.36584	6.151817	1.191744	188.9314
-0.281784	-3.604757	-1.03431	-6.573589	-0.690262	1.30895	-0.417997	6.950375	1.243882	195.2619
-0.229869	-0.732524	-1.086486	2.860986	-0.637966	-1.112483	-0.470307	2.564747	1.295789	201.9788
-0.073587	-2.606559	-1.243283	-0.681004	-0.481409	-4.132835	-0.627175	0.304313	1.346475	252.7581
-0.021201	2.983346	-1.29559	-5.95535	-0.429366	2.596947	-0.679259	-1.273483	1.294186	248.0633
0.030873	1.23811	-1.347786	-1.048083	-0.377115	1.070671	-0.731553	-3.810836	1.241727	260.4925
0.082803	0.594112	-1.378837	0.999831	-0.325067	-2.677399	-0.783822	-2.40692	1.189606	243.0595
0.13487	0.471752	-1.333897	-2.683839	-0.272967	2.216988	-0.835876	-4.152155	1.136999	255.8622
0.18728	3.150785	-1.281671	-1.421602	-0.220662	-0.165806	-0.888248	-0.507125	1.084969	251.6826
0.23943	4.329302	-1.229492	0.877471	-0.168481	0.471752	-0.940418	-4.268075	1.032424	251.1223
0.291429	-2.49064	-1.177094	-4.094195	-0.116511	4.593342	-0.992839	-3.585437	0.980371	254.0396
0.343701	1.998028	-1.125166	-1.969001	-0.064462	3.878503	-1.044913	-4.248755	0.928126	251.5989
0.395606	-0.172246	-1.072746	-0.455605	-0.012195	4.722141	-1.09719	-5.176113	0.875794	237.1991
0.447962	-1.885281	-1.020797	-4.899193	0.039828	4.722141	-1.149533	-6.451229	0.823454	234.2174
0.500184	0.619872	-0.968643	-4.036235	0.092215	5.494939	-1.201501	-9.96746	0.771148	218.0723
0.552412	-2.2266	-0.916159	-3.572557	0.144432	7.729613	-1.25413	-9.606821	0.718913	214.0023
0.60418	2.390867	-0.863654	-3.475957	0.196072	3.182985	-1.306163	-4.905633	0.666649	201.586
0.65631	1.37335	-0.81186	-4.139275	0.248495	7.671653	-1.358451	-5.749271	0.614345	196.6208
0.708695	3.395505	-0.759593	-4.648034	0.300528	5.739658	-1.374302	-5.865191	0.561992	190.4834
0.760876	-0.687445	-0.70738	-2.40048	0.352579	2.957586	-1.323507	-0.455605	0.509726	184.3977
0.81288	5.359699	-0.655206	-2.2588	0.404979	4.155423	-1.271229	-1.943241	0.457608	166.1017
0.865016	-3.566117	-0.603241	-2.2588	0.457001	1.48283	-1.218729	-5.639792	0.405245	167.8083
0.91729	2.931826	-0.551089	-3.160398	0.509307	1.24455	-1.166506	-4.132836	0.353037	157.2853
0.969201	2.906066	-0.499077	-2.4198	0.561081	-0.552205	-1.114452	-4.319595	0.300713	145.2426
1.021493	0.626312	-0.446526	-1.054523	0.613378	2.036668	-1.062473	-2.50352	0.248566	123.6364
1.073321	-0.668125	-0.39469	-0.339685	0.665759	-0.474925	-1.009947	-0.777604	0.196353	118.6454
1.125561	1.006271	-0.342103	1.41199	0.717498	0.735792	-0.958111	-0.919284	0.143977	119.824

1.177945	-2.625879	-0.29043	-2.25236	0.769868	1.29607	-0.905578	0.503952	0.091762	126.2575
1.229981	7.330334	-0.23803	-0.082086	0.82184	1.869229	-0.853548	-3.559677	0.039312	115.9793
1.282029	4.638421	-0.18611	3.221625	0.874086	2.139708	-0.801415	-3.546797	-0.012675	118.8322
1.334198	3.646664	-0.133967	-0.758284	0.926238	0.104673	-0.749157	0.413792	-0.065027	99.04213
1.382898	1.096431	-0.081674	-4.371115	0.978576	3.872063	-0.69697	0.845271	-0.117142	89.52384
1.360366	2.629147	-0.029469	-0.764724	1.030646	0.053154	-0.645026	0.574792	-0.169187	80.1279
1.308066	-0.346125	0.022681	1.38623	1.082515	0.375153	-0.592659	-0.236646	-0.221761	51.5215
1.25563	0.974071	0.074616	2.854546	1.134834	4.361502	-0.540488	-3.578997	-0.274127	5.668818
1.203561	1.46995	0.126756	-3.739996	1.187162	2.358667	-0.488228	0.484632	-0.326208	-41.20138
1.150995	1.798389	0.178881	2.854546	1.239045	1.141511	-0.436156	-0.423405	-0.378517	-77.188
1.09894	0.690712	0.231255	2.081748	1.291167	-2.25236	-0.384281	5.726778	-0.430536	-103.9912
1.04669	4.367942	0.283493	-3.823716	1.343406	2.558307	-0.331894	3.498544	-0.483001	-84.63262
0.994132	-2.625879	0.335389	0.491072	1.386083	-1.299243	-0.279948	4.496741	-0.535145	3.646664
0.941741	-1.827321	0.387675	2.345787	1.350806	7.774693	-0.227752	4.303542	-0.587747	-4.377555
0.785196	1.019151	0.544079	3.608024	1.194072	4.136103	-0.071297	11.63868	-0.744102	-8.512024
0.732698	-0.571525	0.596126	-2.670959	1.141436	1.804829	-0.018862	12.624	-0.796431	-5.337112
0.680668	0.111113	0.648262	1.21879	1.089324	0.703592	0.032933	18.83214	-0.84876	-14.17921
0.628155	-0.371885	0.700232	-1.653442	1.036941	3.859183	0.085081	16.46223	-0.900976	-16.79384
0.57588	-3.662716	0.752632	0.780872	0.984592	-0.185126	0.13746	18.45862	-0.953138	-19.27324
0.52361	1.135071	0.804644	-0.745404	0.932521	3.002666	0.189414	19.06398	-1.005198	-28.12821
0.471225	2.274948	0.85684	0.400913	0.880118	3.608024	0.24166	21.97486	-1.057664	-27.11069
0.418836	3.028426	0.908642	-1.537522	0.827938	5.952178	0.293521	20.78346	-1.109701	-27.16221
0.366681	-2.754679	0.96086	-0.500685	0.775528	6.873095	0.345781	23.03745	-1.161873	-30.15037
0.314452	-2.110681	1.013317	-1.653442	0.723178	2.880306	0.39808	22.95373	-1.21441	-28.50817
0.262302	-1.962561	1.065313	3.382625	0.671253	3.775464	0.449925	19.8561	-1.266829	-29.35825
0.209901	0.928991	1.117373	-4.222995	0.618403	-0.024126	0.502153	21.55626	-1.318938	-26.25418
0.157656	-1.118923	1.169638	-0.520005	0.566396	5.12142	0.554302	18.18815	-1.370817	-26.94325
0.105469	1.663149	1.22159	-1.885281	0.51426	2.796586	0.606266	19.21854	-1.362875	-21.09575
0.053142	1.940068	1.273633	4.290662	0.461708	1.643829	0.658733	14.3628	-1.310753	-10.03186
0.001024	-1.247723	1.32598	0.491072	0.409676	4.644861	0.710784	14.41432	-1.258529	-2.56792
-0.051359	3.363305	1.377536	-1.601922	0.357449	2.584067	0.762754	11.42616	-1.206298	-4.216555
-0.103178	-2.40692	1.368381	-0.133606	0.305103	1.566549	0.814934	13.83472	-1.154236	-0.359006
-0.155501	0.806631	1.31612	1.52791	0.252832	1.49571	0.867215	12.1732	-1.101692	-0.359006
-0.207936	-3.405117	1.263726	-0.970804	0.20079	2.622707	0.919175	5.862018	-1.049616	2.197668
-0.260357	-2.37472	1.211524	0.091794	0.148156	4.522502	0.971481	12.5596	-0.997634	2.165468
-0.312378	-3.269878	1.158967	-3.430877	0.095981	7.484894	1.023626	8.161092	-0.94537	0.471752
-0.364792	-0.661685	1.10692	2.757946	0.04366	2.493907	1.075781	8.61833	-0.89324	3.279585
-0.416801	-1.827321	1.05472	1.27675	-0.008638	3.099265	1.127627	9.526368	-0.841147	-1.853082
-0.469014	2.680666	1.002445	-4.886313	-0.060613	2.674227	1.179961	9.416888	-0.789026	-1.872402
-0.521535	-4.132835	0.950055	-5.356432	-0.112977	4.464542	1.232111	11.2716	-0.736604	2.899626
-0.573674	-2.46488	0.897765	-2.967198	-0.165216	1.521469	1.284296	10.46017	-0.68422	-1.543963

-0.625923	-2.722479	0.845373	-3.147518	-0.217448	-2.20728	1.336264	9.893447	-0.632292	1.882108
-0.678012	-0.565085	0.793085	2.957586	-0.269951	2.693546	1.384034	6.222657	-0.580212	1.17371
-0.730319	-1.267043	0.74078	-2.168641	-0.321998	3.601584	1.357899	4.99906	-0.527887	1.508589
-0.782621	-2.142881	0.688687	-0.410525	-0.374177	1.53435	1.305607	8.354291	-0.475814	-1.312123
-0.834813	-6.509189	0.636281	-3.662716	-0.4263	-3.102438	1.253339	6.802255	-0.423828	0.800191
-0.887325	-2.767559	0.584151	-2.658079	-0.478528	4.561141	1.200957	9.339608	-0.37154	1.624509
-0.93933	1.837029	0.531897	-0.088526	-0.53092	-0.140046	1.148645	8.81153	-0.319272	5.507819
-0.99148	-4.622274	0.479354	-3.566117	-0.583137	4.844501	1.096365	8.199732	-0.267116	8.405811
-1.044032	1.49571	0.426907	0.220593	-0.635314	1.186591	1.043873	7.575053	-0.215149	12.03152
-1.095946	-0.455605	0.374836	-2.123561	-0.687617	-3.231238	0.991866	5.733218	-0.162973	15.67011
-1.14836	-2.26524	0.322819	-1.118923	-0.739838	0.214153	0.939323	9.481288	-0.110885	20.5967
-1.305072	-4.242315	0.165796	-2.45844	-0.896755	-6.283789	0.782588	6.480256	0.045518	36.43906
-1.357324	0.233473	0.113506	-0.758284	-0.94898	-3.192598	0.73033	9.165729	0.097777	48.24999
-1.374571	-0.500685	0.061402	-2.014081	-1.001177	-3.920316	0.678101	5.990817	0.149859	73.36592
-1.324099	-2.928559	0.00927	-0.565085	-1.053354	-2.947879	0.625722	6.016577	0.201966	100.9934
-1.272088	-1.782242	-0.042929	0.246353	-1.105482	-2.883479	0.573419	4.097462	0.254174	117.2158
-1.219695	-6.972868	-0.095063	2.500347	-1.157827	0.677832	0.521233	5.907098	0.306285	115.0197
-1.167699	-2.37472	-0.147551	1.057791	-1.20999	-1.704962	0.469018	5.05058	0.358513	107.9679
-1.115485	-3.314958	-0.200091	-1.131803	-1.262326	-2.838399	0.416651	8.380051	0.41045	107.2531
-1.063102	-4.886313	-0.252076	-3.102438	-1.314538	-1.865961	0.364475	6.126057	0.462625	121.8397
-1.011048	-3.475957	-0.304426	0.845271	-1.366633	-8.692343	0.312219	9.603648	0.514803	128.1122
-0.95891	-5.272712	-0.356618	-1.814442	-1.366932	-3.314957	0.259953	6.679896	0.566847	136.555
-0.906596	-3.907436	-0.408758	0.787312	-1.3147	-2.4198	0.207723	8.92745	0.619006	145.7706
-0.854756	-4.409755	-0.460757	-2.819079			0.155307	9.597208	0.67131	161.8384
-0.802343	-3.160398	-0.51341	-5.491672			0.103007	8.66341	0.723326	171.3438
-0.750102	-2.026961	-0.565354	-5.581831			0.050843	4.316422	0.775285	180.8943
-0.69799	-2.612999	-0.61778	-0.629485			-0.001246	8.985409	0.827596	184.8163
-0.645915	2.107508	-0.67011	1.56011			-0.053511	7.201534	0.879759	196.9685
-0.593814	-1.556842	-0.722258	0.600552			-0.105837	7.246614	0.931941	217.8598
-0.541602	-2.593679	-0.77453	-0.796924			-0.158098	8.296331	0.983962	224.2547
-0.489405	1.791949	-0.826772	0.014514			-0.210438	5.907098	1.036348	229.8961
-0.437132	-0.597285	-0.879156	-2.49064			-0.262611	7.851972	1.08821	257.8521
-0.384897	-0.584405	-0.931202	-1.634122			-0.314849	2.912506	1.140448	253.8851
-0.332828	2.384427	-0.98356	-6.560709			-0.367109	5.965057	1.192466	271.814
-0.280788	1.089991	-1.035963	0.819512			-0.419293	6.724975	1.244583	276.9338
-0.228456	-2.046281	-1.088022	-1.292803			-0.471543	2.416627	1.296595	309.1852
-0.176494	-1.144683	-1.140353	0.297873			-0.523863	2.886746	1.348918	312.2957
-0.124076	1.28963	-1.192602	-7.056587			-0.576073	0.284993	1.3864	292.1128
-0.072244	4.825181	-1.244772	1.128631			-0.628268	1.23167	1.345608	290.1679
-0.020113	3.981543	-1.296842	-5.96823			-0.68061	-0.706765	1.293102	289.1311
0.031999	0.355833	-1.349266	0.078913			-0.73282	-2.52928	1.240999	271.1378

0.084197	0.555472	-1.378456	-2.619439			-0.785183	-1.833762	1.188696	254.6128
0.136299	-2.452	-1.332108	-5.156792			-0.837312	-0.964364	1.136337	274.6669
0.188448	-2.31676	-1.279975	-2.773999			-0.889607	-4.313155	1.083974	246.6916
0.240915	1.972268	-1.227736	-0.481365			-0.941834	-1.060964	1.031694	253.4987
0.292887	-0.069206	-1.175555	-2.954319			-0.994091	-1.318563	0.979352	244.7274
0.344928	2.101068	-1.12339	-0.835564			-1.046423	-5.440152	0.927222	236.0656
0.397044	1.959388	-1.071428	-2.17508			-1.098577	-0.848444	0.874983	231.3838
0.449264	-3.108878	-1.019077	-2.31676			-1.150748	-3.578997	0.822683	215.4384
0.605684	-3.443757	-0.862437	-4.461274			-1.30737	-7.681266	0.665615	188.2874
0.65796	3.067065	-0.810253	-0.404085			-1.359725	-6.895588	0.613342	185.3121
0.709995	-0.610165	-0.75822	-0.397645			-1.373331	-3.244118	0.561047	177.0561
0.761898	2.139708					-1.322151	-3.591877	0.508945	166.1983
0.814165	2.487467					-1.269945	-0.474925	0.456732	163.281
0.866443	-0.474925					-1.217816	-2.226601	0.404396	158.8116
0.918341	2.049548					-1.165517	-2.284561	0.352225	134.6295
0.970552	1.33471					-1.113304	-3.778636	0.299809	136.1558
1.022671	3.092825					-1.061429	0.291433	0.247724	117.6601
1.074747	-1.653442							0.195306	123.8296
1.126866	2.674226							0.143106	115.2966
1.179109	1.37335							0.090834	100.5426
1.231099	2.964026							0.038507	98.65573
1.283327	0.368713							-0.013616	76.97875
1.335566	4.129663							-0.065942	79.7093
1.383773	0.484632							-0.117968	72.0908
1.358966	3.826983							-0.170402	57.63304
1.306764	0.227033							-0.222406	25.43313
1.254573	-3.430877							-0.274958	-18.80956
1.202007	-1.138243							-0.326873	-52.97367
1.149806	0.233473							-0.379295	-86.12026
1.097406	1.22523							-0.431459	-110.985
								-0.483761	-101.5247
								-0.536101	-12.65293
								-0.58826	-0.127166
								-0.640402	-4.860554
								-0.692865	-5.633352
								-0.745364	-9.452261
								-0.797363	-9.709861
								-0.849464	-12.85257
								-0.901918	-14.50765
								-0.954141	-20.67071
								-1.006352	-21.41131

								-1.058568	-21.05067
								-1.110717	-25.65526
								-1.163287	-24.67638
								-1.215242	-26.97545
								-1.267495	-24.2449
								-1.361978	-11.95098
								-1.309857	-11.7449
								-1.257557	-5.568952
								-1.205476	-1.009444
								-1.153315	-0.410526
								-1.10088	-1.640562
								-1.048892	-0.784045
								-0.996592	0.581232
								-0.944574	-2.278121
								-0.892355	-0.127166
								-0.839931	-0.069207
								-0.78794	4.219822
								-0.735802	2.899626
								-0.683646	2.841666
								-0.631517	-0.352566

B.1.1.4-Natural Oxide Control

Natural Oxide Control 1		Natural Oxide Control 2		Natural Oxide Control 3		Natural Oxide Control 4		Natural Oxide Control 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
0.466081	12327.89	-0.110738	5545.623	1.066543	34659.23	-0.459358	1308.825	-0.564877	290.4899
0.413846	11707.48	-0.16296	4882.948	1.118831	35858.31	-0.511308	852.5846	-0.512703	347.5289
0.361605	11084.19	-0.215763	4227.357	1.171175	37040.71	-0.563854	502.1142	-0.460461	467.5637
0.309361	10466.84	-0.267618	3575.482	1.222983	38230.83	-0.615596	289.9361	-0.408483	723.1796
0.257072	9854.031	-0.319828	2931.489	1.275214	39410.08	-0.668255	191.6555	-0.356342	1303.416
0.204902	9224.476	-0.371975	2298.026	1.327622	40599.38	-0.720167	129.1491	-0.304253	2080.046
0.15238	8597.987	-0.424066	1678.487	1.378573	41809.01	-0.772771	31.29995	-0.252181	2909.465
0.100459	7974.84	-0.476241	1085.171	1.366613	41619.91	-0.824832	-93.94483	-0.200145	3784.652
0.048046	7353.992	-0.528785	549.4352	1.314231	40554.96	-0.877059	-250.3527	-0.14774	4701.604
-0.004126	6730.24	-0.580905	153.8464	1.261889	39468.65	-0.929514	-460.7598	-0.095406	5665.864
-0.0563	6108.014	-0.633021	0.780872	1.209484	38376.87	-0.981544	-703.7725	-0.043412	6662.085
-0.108666	5497.4	-0.685339	-37.78819	1.157285	37334.58	-1.033601	-976.5186	0.008575	7697.179

-0.160724	4884.905	-0.737587	-65.08727	1.104596	36312.55	-1.086013	-1263.13	0.060409	8751.767
-0.213144	4272.874	-0.789934	-105.086	1.052634	35171.26	-1.138481	-1559.041	0.112693	9810.091
-0.265358	3672.152	-0.842243	-177.1945	1.000382	34042.57	-1.190578	-1858.603	0.164901	10855.17
-0.317344	3067.669	-0.894368	-248.3499	0.947942	32904.79	-1.242744	-2163.916	0.217319	11870.7
-0.369928	2482.538	-0.946438	-371.4759	0.895606	31789	-1.295127	-2450.353	0.269074	12859.74
-0.421895	1908.942	-0.998581	-534.9999	0.843525	30648.99	-1.347102	-2724.999	0.321193	13843.76
-0.474315	1359.927	-1.050845	-702.2398	0.79111	29499.2	-1.379499	-2844.48	0.373298	14809.89
-0.526578	879.2912	-1.103182	-840.635	0.738894	28352.61	-1.33452	-2416.839	0.425498	15768.3
-0.578655	551.9146	-1.155219	-949.1809	0.686695	27201.82	-1.282108	-2004.037	0.478041	16739.14
-0.630877	386.6711	-1.207991	-1028.856	0.634487	26064.33	-1.229837	-1625.727	0.529742	17686.24
-0.683099	301.4959	-1.260236	-1084.317	0.582138	24911.03	-1.177698	-1281.259	0.582205	18634.47
-0.735206	203.6983	-1.312376	-1131.226	0.529991	23761.82	-1.125478	-979.2298	0.634081	19576.03
-0.787613	72.85716	-1.364437	-1181.761	0.477543	22606.24	-1.073389	-715.6156	0.686008	20521.63
-0.839855	-109.9611	-1.369473	-1004.99	0.425177	21448.73	-1.020991	-484.0983	0.738374	21464.16
-0.89191	-340.6928	-1.317283	-670.4971	0.373025	20319.89	-0.968825	-299.889	0.790482	22410.19
-0.944272	-615.6864	-1.265198	-452.8708	0.320828	19161.94	-0.916753	-148.221	0.842489	23339.81
-0.996675	-928.0964	-1.21294	-299.8118	0.268498	18014.87	-0.864704	-44.31833	0.894781	24272.39
-1.048781	-1265.184	-1.160839	-192.8823	0.216045	16873.93	-0.812415	17.48619	0.946913	25209.47
-1.10102	-1611.069	-1.108554	-118.23	0.163885	15737.62	-0.760194	61.32959	0.998871	26135.9
-1.15329	-1974.284	-1.056316	-60.28949	0.111257	14606.49	-0.707967	81.0295	1.051168	27075.32
-1.205513	-2334.26	-1.004152	-26.07386	0.059444	13483.47	-0.655955	100.9484	1.103128	28033.13
-1.25781	-2688.291	-0.952098	-0.468485	0.007387	12351.3	-0.603936	122.4128	1.15536	29022.77
-1.310093	-3038.239	-0.89999	16.07583	-0.044826	11222.72	-0.551681	152.1398	1.207185	30009.4
-1.362066	-3376.409	-0.847866	29.46456	-0.097155	10096.63	-0.499645	191.5525	1.259608	30958.64
-1.267607	-2265.597	-0.690945	58.496	-0.254085	6755.498	-0.342874	976.6767	1.380461	33244.98
-1.215351	-1819.081	-0.638862	64.2147	-0.306322	5660.287	-0.290916	1478.197	1.329902	32444.39
-1.162916	-1420.922	-0.586989	75.41383	-0.358484	4594.12	-0.238883	1996.693	1.277159	31546.74
-1.110648	-1057.263	-0.534723	87.40508	-0.410234	3532.482	-0.18669	2526.118	1.224874	30642.38
-1.058814	-741.6396	-0.482557	137.6627	-0.462712	2530.69	-0.134798	3100.423	1.17257	29827.41
-1.006424	-476.834	-0.430252	306.6285	-0.514953	1622.221	-0.082592	3701.66	1.12036	28953.86
-0.954125	-267.7986	-0.378021	477.3847	-0.567417	956.249	-0.030229	4343.276	1.06816	28061.18
-0.902188	-114.6107	-0.326174	709.5332	-0.619558	623.714	0.021851	4997.154	1.015819	27218.84
-0.850008	-13.63181	-0.274171	1232.054	-0.671731	467.1258	0.073655	5657.575	0.963272	26304.07
-0.797514	54.84453	-0.221888	1887.574	-0.724172	304.8125	0.126179	6301.253	0.911209	25406.38
-0.745575	99.30617	-0.169562	2568.429	-0.77626	56.93752	0.178046	6925.842	0.858779	24505.86
-0.693394	131.3773	-0.117645	3310.521	-0.828408	-256.6059	0.230238	7536.45	0.806518	23618.68
-0.641102	164.1439	-0.065537	4087.635	-0.88074	-657.4497	0.282287	8147.573	0.754297	22719.03
-0.589039	194.5213	-0.013207	4875.709	-0.932849	-1156.207	0.334544	8747.91	0.701717	21805.21
-0.536847	234.8485	0.038793	5633.954	-0.985415	-1725.855	0.386356	9330.71	0.649937	20895.53
-0.484542	297.4387	0.090716	6376.768	-1.037385	-2349.078	0.438854	9916.905	0.597268	19979.51
-0.432629	429.3617	0.142851	7093.436	-1.089484	-2992.554	0.490946	10505.82	0.545279	19061.41

-0.380372	733.3741	0.195019	7786.167	-1.141824	-3648.189	0.542878	11093.4	0.492969	18138.34
-0.328287	1244.045	0.247039	8475.685	-1.194056	-4299.058	0.595318	11677.19	0.440576	17226.94
-0.276127	1813.862	0.299233	9156.54	-1.246211	-4950.475	0.647392	12270.77	0.388104	16318.59
-0.224172	2413.759	0.351456	9826.043	-1.298254	-5591.265	0.699793	12840.43	0.336122	15415.62
-0.171951	3033.331	0.403585	10495.99	-1.35049	-6196.391	0.751483	13422.31	0.28388	14511.69
-0.119832	3678.077	0.455578	11181.77	-1.37794	-6390.524	0.803612	13997.19	0.231629	13637.25
-0.067719	4336.476	0.507761	11858.05	-1.330999	-5465.067	0.855938	14582.92	0.179181	12738.13
-0.015629	5025.207	0.559928	12537.35	-1.278755	-4575.43	0.908136	15153.74	0.127164	11842.3
0.036417	5739.956	0.612203	13218.29	-1.226814	-3749.084	0.95998	15722.28	0.074807	10930.34
0.088543	6485.314	0.664351	13900.83	-1.174268	-2990.506	1.012618	16292.2	0.022638	10023.77
0.140541	7236.829	0.716381	14581.93	-1.122371	-2318.52	1.064102	16856.46	-0.02958	9138.322
0.192957	7983.199	0.768626	15264.92	-1.0701	-1709.073	1.116325	17434.3	-0.081501	8248.494
0.244924	8712.213	0.820475	15966.37	-1.017925	-1178.399	1.168641	18037.85	-0.134115	7373.421
0.297183	9416.375	0.872903	16666.39	-0.965761	-738.6965	1.220701	18627.75	-0.186083	6491.632
0.349249	10107.64	0.924841	17367.01	-0.913327	-388.5032	1.27275	19236.53	-0.238521	5618.884
0.401487	10782.61	0.977016	18089.05	-0.86147	-138.561	1.324895	19791.64	-0.290898	4751.958
0.453369	11442.1	1.029013	18912.26	-0.809327	33.8373	1.37654	20360.17	-0.342898	3902.272
0.505663	12097.76	1.081344	19685.77	-0.75705	148.044	1.369114	20388.69	-0.39514	3073.221
0.557711	12750.62	1.133105	20408.98	-0.704826	214.511	1.317048	19871.25	-0.447391	2273.316
0.609842	13414.76	1.18552	21144.87	-0.652764	265.11	1.264319	19306.8	-0.499579	1548.419
0.661753	14072.6	1.237656	21855.82	-0.600664	312.8496	1.212317	18780.1	-0.551878	995.9129
0.818319	16026.86	1.385644	23909.28	-0.444004	619.8629	1.055155	17171.52	-0.708494	383.9856
0.870373	16670.34	1.352129	23644.85	-0.391861	1053.622	1.002772	16617.88	-0.760732	166.7135
0.922848	17315.34	1.299642	23137.25	-0.339776	1895.617	0.950555	16112.05	-0.813016	-130.4789
0.974764	17954.21	1.247065	22607.15	-0.287724	2893.513	0.898371	15587.98	-0.865335	-486.172
1.026858	18594.21	1.194896	22029.91	-0.235567	3945.124	0.846104	15091.11	-0.917444	-923.0152
1.079035	19236.48	1.14268	21438.27	-0.183523	5064.691	0.793658	14525.9	-0.969769	-1413.381
1.131197	19879.6	1.090452	20835.09	-0.131183	6252.077	0.741572	13964.29	-1.021914	-1943.462
1.183273	20522.12	1.037838	20217.86	-0.079069	7515.913	0.689068	13404.52	-1.074269	-2486.366
1.235473	21155.95	0.985875	19583.03	-0.027048	8846.628	0.636789	12847.59	-1.126557	-3056.052
1.287513	21785.62	0.933487	18931.16	0.024939	10218.72	0.584879	12295.51	-1.178822	-3620.291
1.339698	22419.23	0.881157	18281.62	0.077145	11572.78	0.532417	11739.24	-1.230764	-4194.589
1.385128	22979.96	0.828885	17624.03	0.129235	12882.63	0.480057	11172.37	-1.282721	-4767.148
1.354119	22647.73	0.77653	16963.87	0.181726	14156.26	0.427903	10617.49	-1.335107	-5340.789
1.301697	22060.19	0.724404	16295.52	0.233358	15400.5	0.375448	10068.76	-1.378791	-5805.124
1.24958	21462.93	0.672075	15627.84	0.285643	16617.87	0.323581	9583.931	-1.345859	-5243.075
1.197193	20862.82	0.619803	14964.82	0.337561	17830.01	0.271267	9029.08	-1.293957	-4495.703
1.144983	20247.69	0.56738	14294.13	0.389965	19029.15	0.218642	8473.308	-1.241448	-3809.15
1.092555	19648.32	0.51532	13625.63	0.441933	20208.62	0.166474	7900.535	-1.189651	-3159.369
1.040274	19055.14	0.462762	12959.95	0.494203	21384.93	0.114231	7336.855	-1.137394	-2544.345
0.98795	18443.41	0.410635	12288.31	0.546268	22565.19	0.062139	6768.204	-1.085036	-1980.956

0.935781	17831.32	0.35864	11609.35	0.59848	23752.25	0.009705	6212.258	-1.032866	-1457.463
0.883352	17210.73	0.306404	10942.15	0.650825	24907.84	-0.042373	5646.466	-0.980523	-997.4614
0.831322	16586.29	0.25399	10276.11	0.70291	26092.72	-0.094811	5087.353	-0.928442	-603.8369
0.778747	15966.18	0.20172	9607.385	0.754681	27266.64	-0.146766	4537.32	-0.876362	-291.6652
0.726673	15343.31	0.149394	8941.934	0.806732	28431.39	-0.199207	3982.978	-0.824042	-59.35569
0.674249	14718.08	0.097293	8277.552	0.859006	29623.23	-0.251443	3446.605	-0.772196	101.1802
0.622036	14100.48	0.044858	7603.98	0.911091	30783.43	-0.303729	2903.669	-0.719824	198.0826
0.569761	13494.66	-0.007338	6936.075	0.963152	31961.2	-0.355944	2376.974	-0.667631	269.6888
0.517475	12894.48	-0.059518	6272.865	1.015514	33149.64	-0.408112	1860.255	-0.615465	317.1708
0.46524	12270.02	-0.111851	5609.552	1.067687	34327.67	-0.460004	1361.008	-0.563325	357.8522
0.413012	11644.48	-0.16406	4946.092	1.119788	35509.85	-0.512695	917.9891	-0.511209	421.4019
0.360558	11025.42	-0.21621	4291.299	1.171837	36689.23	-0.564478	577.4492	-0.458864	550.9293
				1.224067	37861.64			-0.406646	783.9022

B.1.2 Pac 1

B.1.2.1-Pac 1 Alodine

Pac 1 Alodine 1		Pac 1 Alodine 2		Pac 1 Alodine 3		Pac 1 Alodine 4		Pac 1 Alodine 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-0.126992	8559.836	-0.860739	-213.9346	-1.321957	-3114.212	-0.121576	4495.873	0.409881	13156.9
-0.179212	7582.039	-0.91265	-400.0308	-1.37311	-3220.8	-0.073892	5347.047	0.358871	12541.11
-0.231361	6608.215	-0.96501	-633.2032	-1.36015	-2726.982	-0.025013	6212.684	0.306463	11859.21
-0.283717	5638.333	-1.017222	-894.5634	-1.307827	-2061.572	0.023728	7107.071	0.253522	11233.09
-0.336032	4678.716	-1.069393	-1167.728	-1.255873	-1542.039	0.072306	7991.527	0.202116	10567.27
-0.388039	3723.904	-1.121677	-1446.45	-1.203453	-1130.17	0.120954	8890.544	0.150555	9928.872
-0.440088	2803.636	-1.173838	-1714.225	-1.151223	-792.7473	0.169669	9778.613	0.098857	9293.334
-0.492594	1925.956	-1.226076	-1965.075	-1.0991	-524.6444	0.21886	10632.74	0.046365	8640.261
-0.544745	1145.301	-1.278272	-2194.403	-1.046944	-313.355	0.267747	11485.34	-0.00533	7981.945
-0.596837	616.6944	-1.330683	-2384.279	-0.994729	-146.5981	0.316278	12368.81	-0.057242	7322.174
-0.649048	388.6933	-1.377952	-2505.518	-0.942536	-36.21683	0.366698	13256.48	-0.109547	6680.976
-0.701468	271.3761	-1.351164	-2112.138	-0.890418	40.12273	0.416721	14147	-0.160995	6025.687
-0.753512	125.665	-1.298945	-1647.674	-0.838275	86.12996	0.466396	15016.14	-0.212586	5370.102
-0.805687	-71.93297	-1.246651	-1269.042	-0.786126	119.0447	0.514325	15881.26	-0.264037	4744.406
-0.858044	-304.9766	-1.194165	-951.5122	-0.734191	147.3291	0.564688	16722.14	-0.31653	4090.18
-0.910304	-604.571	-1.142142	-684.4783	-0.681764	164.2405	0.612088	17583.53	-0.368507	3462.314

-0.962594	-962.8208	-1.089868	-462.1895	-0.629588	183.6184	0.662502	18459.28	-0.418952	2888.008
-1.014965	-1365.944	-1.037714	-277.2139	-0.577426	198.4111	0.713133	19348.57	-0.470994	2381.085
-1.066896	-1785.767	-0.985384	-141.7939	-0.52537	219.5922	0.763193	20185.83	-0.523363	2076.647
-1.119076	-2189.425	-0.933444	-42.79849	-0.473167	266.0824	0.812467	21077.63	-0.576137	1944.634
-1.171486	-2559.086	-0.881232	19.36022	-0.421064	394.135	0.862026	21927.89	-0.629551	1879.281
-1.223548	-2844.035	-0.82904	58.10316	-0.369004	806.0364	0.910597	22811.72	-0.68222	1767.354
-1.27607	-3050.572	-0.776918	88.5514	-0.316882	1517.333	0.961255	23670.99	-0.735207	1668.159
-1.328203	-3171.772	-0.724755	111.9801	-0.264642	2366.239	1.010997	24549.15	-0.787894	1527.626
-1.37688	-3199.071	-0.672648	127.5133	-0.212675	3308.718	1.063165	25424.2	-0.839607	1348.8
-1.353574	-2554.372	-0.620504	141.0437	-0.160498	4301.867	1.111372	26342.75	-0.89215	1137.311
-1.301277	-1872.056	-0.56834	158.9469	-0.108374	5356.931	1.162629	27339.73	-0.944153	915.9879
-1.249171	-1361.733	-0.51618	184.3848	-0.056271	6434.612	1.213892	28287.21	-0.995928	718.1709
-1.196818	-964.9009	-0.463909	228.9108	-0.004253	7521.696	1.266808	29256.2	-1.049933	553.2558
-1.144834	-652.2462	-0.411835	348.5078	0.047925	8612.167	1.317715	30230.73	-1.102061	426.3495
-1.092595	-406.548	-0.35977	674.2614	0.100021	9702.388	1.37033	31162.52	-1.154133	367.385
-1.040217	-220.278	-0.307684	1174.655	0.152112	10757.24	1.37557	31453.23	-1.206474	338.7721
-0.988174	-78.70784	-0.255481	1728.21	0.204237	11812.8	1.323205	30789.93	-1.259977	306.6623
-0.936236	21.5627	-0.203476	2317.778	0.256456	12864.42	1.270762	30107.34	-1.288483	435.301
-0.883779	86.31672	-0.151136	2927.78	0.308514	13897.64	1.218566	29316.72	-1.245293	782.1199
-0.831909	133.5862	-0.099173	3557.443	0.36059	14931.68	1.166503	28521	-1.196182	981.0187
-0.727202	199.9051	0.004879	4845.319	0.464766	17006.65	1.061873	27032.71	-1.097779	1192.791
-0.675028	223.5592	0.057069	5466.482	0.516941	18035.1	1.00981	26204.92	-1.047928	1235.643
-0.623094	248.1986	0.109179	6087.606	0.569181	19045.64	0.958417	25457.32	-0.999361	1262.034
-0.570877	271.7754	0.161317	6704.274	0.621204	20072.99	0.9043	24638.82	-0.948802	1285.262
-0.518847	302.1785	0.213356	7308.777	0.673375	21123.91	0.852456	23752.75	-0.899781	1313.437
-0.466502	365.8893	0.265654	7915.727	0.725479	22166.85	0.799205	22916.44	-0.848664	1270.656
-0.41453	530.1797	0.317798	8499.216	0.777602	23205.96	0.747814	22116.19	-0.799106	1273.001
-0.362363	993.382	0.369699	9081.952	0.829708	24254.69	0.694967	21200.5	-0.749098	1251.652
-0.310245	1753.358	0.421975	9663.542	0.881899	25312.17	0.643822	20388.58	-0.699503	1195.54
-0.258204	2641.851	0.473976	10234.65	0.933957	26343.6	0.59121	19535.43	-0.650648	1174.61
-0.20606	3631.22	0.526104	10809.82	0.986032	27363.57	0.538779	18700.3	-0.60014	1142.391
-0.15404	4700.464	0.578284	11371.38	1.038188	28413.01	0.487299	17864.9	-0.550474	1107.834
-0.101826	5831.945	0.630359	11931.68	1.090275	29408.66	0.433904	16996.25	-0.500617	1085.268
-0.049659	6981.902	0.682663	12489.47	1.142509	30460.28	0.382312	16112.93	-0.450327	1044.851
0.002438	8145.912	0.734674	13049.09	1.194552	31524.31	0.330584	15238.3	-0.40093	1059.637
0.054489	9331.528	0.786718	13601.25	1.246697	32554.78	0.279132	14392.9	-0.352479	1203.107
0.10656	10488.12	0.83886	14162.52	1.298709	33613.71	0.227637	13525.78	-0.301904	1537.284
0.158694	11615.12	0.891035	14705.85	1.350835	34709.96	0.174591	12672.94	-0.251828	2017.45
0.21076	12733.97	0.943006	15258.62	1.385902	35557.6	0.123553	11804.94	-0.201601	2541.046
0.262984	13844.05	0.995294	15824.39	1.343031	35008.14	0.070912	10919.41	-0.152826	3166.04
0.315047	14936.83	1.047314	16417.28	1.290527	34186.35	0.019246	10074.62	-0.103709	3847.417

0.367046	16031.88	1.099472	16999.29	1.238403	33354.28	-0.032484	9191.812	-0.053537	4571.716
0.419243	17111.88	1.151652	17583.33	1.185997	32481.06	-0.084595	8367.712	-0.004796	5346.183
0.471284	18183.39	1.203726	18194.5	1.133809	31612.47	-0.135609	7497.939	0.045613	6077.006
0.523521	19247.89	1.255807	18743.35	1.081534	30716.3	-0.187107	6643.223	0.095226	6843.314
0.575707	20298.3	1.307943	19279.93	1.02915	29776.11	-0.239494	5795.353	0.145555	7617.497
0.62782	21360.18	1.360002	19850	0.976876	28861.71	-0.291503	4934.519	0.195034	8358.747
0.679826	22398.4	1.38263	20140.94	0.9247	27953.7	-0.343517	4087.306	0.245148	9108.762
0.732021	23461.65	1.333551	19783.21	0.872352	26996.45	-0.395998	3257.05	0.295246	9795.401
0.784074	24505.35	1.281208	19416.62	0.820125	26064.06	-0.446949	2457.165	0.345443	10521.7
0.836171	25573.71	1.228881	18943.04	0.767701	25148.74	-0.498387	1684.128	0.395202	11237.32
0.888297	26617.78	1.176534	18473.73	0.715453	24180.16	-0.550879	1016.624	0.44637	11915.83
0.940581	27697.15	1.12412	17981.25	0.663229	23219.62	-0.603106	588.3199	0.496409	12633.17
0.992603	28756.04	1.07181	17455.42	0.610971	22261.75	-0.654658	415.7476	0.547419	13360.82
1.044688	29805.34	1.019577	16925.92	0.558696	21317.84	-0.708052	290.7025	0.598756	14070.22
1.096874	30863.68	0.967395	16398.74	0.506466	20380.93	-0.759622	145.146	0.649518	14814.07
1.149015	31913.39	0.915088	15832.63	0.454183	19446.34	-0.810757	-37.78172	0.700375	15517.92
1.201144	32956.67	0.86275	15264.03	0.401875	18473.97	-0.863803	-276.338	0.752675	16283.74
1.305233	34994.21	0.758148	14170.08	0.297449	16510.68	-0.968299	-908.2548	0.857373	17769.91
1.35752	36007.53	0.706064	13575.32	0.245172	15553.94	-1.020137	-1275.456	0.908925	18533.27
1.383742	36626.5	0.653751	12985.48	0.192943	14582.27	-1.072462	-1647.539	0.96094	19314.16
1.335899	35870.04	0.601419	12426.26	0.140592	13595.8	-1.124087	-1980.454	1.013025	20041.59
1.283661	35005.5	0.548939	11860.21	0.088339	12614.97	-1.17731	-2294.615	1.065074	20762.15
1.231261	34111.69	0.496951	11297.49	0.036206	11622.33	-1.231032	-2522.301	1.117258	21519.8
1.179054	33216.67	0.444657	10745.47	-0.015796	10639.35	-1.280742	-2720.678	1.16946	22284.65
1.126766	32299.07	0.392424	10191.04	-0.068178	9648.975	-1.334151	-2859.279	1.221463	23073.67
1.074396	31351.98	0.340123	9621.521	-0.120251	8689.364	-1.372141	-2808.789	1.273581	23841.85
1.022254	30413.37	0.287796	9079.518	-0.172692	7712.255	-1.335326	-2186.926	1.325678	24640.04
0.96993	29447.05	0.235685	8527.121	-0.224838	6733.801	-1.283418	-1660.277	1.377232	25400.97
0.917667	28478.03	0.183482	7986.792	-0.277141	5780.264	-1.233898	-1233.268	1.36805	25407.54
0.865192	27486.95	0.130986	7451.816	-0.32941	4806.717	-1.181612	-896.695	1.315675	24910.21
0.813089	26499.67	0.078853	6924.58	-0.381575	3865.056	-1.130341	-618.256	1.263325	24277.93
0.760739	25497.96	0.026728	6400.66	-0.43373	2942.856	-1.078874	-383.963	1.211043	23705.15
0.708456	24502.26	-0.025491	5871.119	-0.485964	2047.215	-1.027963	-197.2486	1.158692	23136.09
0.656156	23520.7	-0.077845	5328.209	-0.53821	1229.923	-0.975682	-87.04115	1.106257	22530.69
0.604035	22536.06	-0.130101	4781.151	-0.59037	635.145	-0.922817	9.519953	1.05397	21952.29
0.551865	21534.69	-0.182199	4235.741	-0.642744	366.617	-0.871032	70.40999	1.00173	21302.05
0.499357	20540.55	-0.234497	3698.208	-0.694705	235.6213	-0.819388	94.46331	0.94948	20644.08
0.447155	19548.72	-0.286676	3155.028	-0.747028	80.78478	-0.767132	144.122	0.897206	20009.03
0.394805	18551.94	-0.338859	2618.158	-0.799303	-136.0108	-0.714683	166.7714	0.844979	19379.43
0.342635	17538.21	-0.391134	2110.79	-0.851613	-401.3188	-0.662341	184.4621	0.792487	18657.91
0.290529	16532.55	-0.44332	1590.407	-0.903728	-728.2316	-0.609991	204.6321	0.740401	18011.76

0.238115	15546.5	-0.495315	1112.251	-0.956104	-1135.683	-0.557994	233.6313	0.688173	17326.05
0.18608	14599.84	-0.547784	684.8166	-1.008036	-1586.61	-0.505735	260.8209	0.635867	16642.71
0.133645	13604.18	-0.599834	403.7306	-1.060352	-2055.892	-0.4532	331.4547	0.583864	15942.97
0.081492	12613.38	-0.651916	261.7354	-1.112512	-2514.965	-0.40148	528.8595	0.53126	15250.12
0.02924	11605.16	-0.704284	181.1906	-1.164963	-2960.052	-0.349372	1025.672	0.478904	14547.21
-0.023075	10617.89	-0.756712	68.14309	-1.217061	-3366.537	-0.297231	1737.522	0.426975	13849.3
-0.075288	9626.654	-0.808864	-80.97471	-1.269328	-3712.299	-0.245152	2529.286	0.37449	13130.14
-0.127452	8638.52	-0.861018	-261.7643	-1.321551	-3981.548	-0.192967	3408.679	0.322431	12395.73
-0.179638	7659.757	-0.913268	-491.5236	-1.372748	-4177.819	-0.14083	4361.263	0.270118	11689.03
-0.231964	6685.476	-0.965594	-755.7625	-1.360098	-3665.113	-0.088785	5338.21	0.218045	10979.99
-0.284157	5711.736	-1.017854	-1050.92	-1.308152	-2883.918	-0.036752	6339.036	0.165573	10263.25
		-1.07004	-1355.112	-1.255827	-2240.925	0.015338	7362.512	0.113172	9542.277
		-1.122275	-1662.274	-1.20352	-1698.537	0.067373	8412.534	0.060984	8829.582
				-1.151302	-1245.819	0.119489	9439.984	0.009077	8113.145
				-1.046941	-549.1872	0.223901	11457.17	-0.095214	6696.842
				-0.994732	-305.6271	0.275944	12447.28		
				-0.942655	-116.5556	0.328076	13399.49		
				-0.890432	8.79865				
				-0.838352	89.65907				
				-0.786115	146.6529				
				-0.734002	190.0198				
				-0.681767	222.8572				
				-0.629714	246.8913				

B.1.2.2-Pac 1 Anodize Type II

Pac 1 Anodize Type II 1		Pac 1 Anodize Type II 2		Pac 1 Anodize Type II 3		Pac 1 Anodize Type II 4		Pac 1 Anodize Type II 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-1.13019	-4.242315	0.287956	623.4371	0.163318	395.6742	-1.11499	-94.80779	-1.379744	-44.69829
-1.0779	-1.279923	0.340044	674.4546	0.111152	375.9614	-1.06272	-62.80752	-1.337721	-33.40256
-1.025788	2.165467	0.392224	727.6167	0.058845	356.7703	-1.010554	-39.01178	-1.285532	-21.54011
-0.973583	-4.171476	0.444344	773.5338	0.006821	333.1613	-0.958429	-17.50224	-1.233203	-14.55273
-0.921357	-2.065601	0.496594	829.5745	-0.045452	310.4217	-0.906363	-3.920316	-1.180946	-8.711663
-0.86917	0.626312	0.5486	870.7389	-0.097794	287.9397	-0.854024	3.769023	-1.128809	-6.908468
-0.817156	-1.492443	0.600649	918.6009	-0.149968	253.898	-0.802029	4.342182	-1.07664	-3.295638
-0.764795	-2.007641	0.652831	957.9749	-0.202343	219.0061	-0.749722	11.89628	-1.024466	-1.640562

-0.712704	-1.608362	0.704905	996.0674	-0.254466	180.1344	-0.697464	14.35636	-0.972213	-1.808002
-0.660575	-4.396875	0.757116	1035.165	-0.306693	140.5865	-0.64547	11.58072	-0.920297	2.687106
-0.608423	-1.151124	0.809199	1079.227	-0.358958	106.7443	-0.593265	16.90015	-0.867911	-0.004807
-0.556285	-2.342521	0.861333	1123.785	-0.411219	74.216	-0.541214	20.18454	-0.815798	0.420232
-0.504129	-4.190796	0.913325	1164.563	-0.463413	40.40609	-0.488896	24.42849	-0.76346	4.9089
-0.452001	-0.507125	0.96547	1217.101	-0.515792	8.264131	-0.436674	41.50088	-0.711456	3.794783
-0.399772	6.177577	1.017686	1260.603	-0.568041	-27.29745	-0.384752	76.77911	-0.65938	3.878503
-0.347605	7.877732	1.069791	1307.711	-0.620132	-48.56872	-0.33266	156.0295	-0.607213	4.606221
-0.295501	17.11911	1.121817	1360.796	-0.672324	-64.48191	-0.280475	248.7524	-0.555095	5.462739
-0.243454	23.57197	1.174085	1401.51	-0.724597	-75.32041	-0.228387	346.5822	-0.502915	3.665983
-0.191347	30.85559	1.226044	1422.948	-0.776916	-91.76168	-0.176277	460.5763	-0.45074	6.692775
-0.139122	38.08769	1.278288	1473.38	-0.829176	-99.28358	-0.124083	567.493	-0.398607	9.416888
-0.087085	48.16627	1.330279	1529.865	-0.881313	-106.6187	-0.071898	679.1043	-0.346485	20.58382
-0.034938	60.29275	1.380872	1574.893	-0.933652	-107.0051	-0.01971	792.828	-0.294178	36.35534
0.017201	72.11012	1.36409	1563.14	-0.985874	-97.60275	0.032294	917.6027	-0.242123	55.66885
0.069294	80.92646	1.311767	1526.155	-1.038003	-94.89151	0.084532	1045.056	-0.190038	77.33295
0.121334	87.80436	1.259428	1500.557	-1.09013	-94.40207	0.136514	1174.526	-0.138001	106.4224
0.173467	96.78814	1.20719	1457.125	-1.142519	-100.6231	0.188656	1304.124	-0.085741	135.1254
0.225539	108.8631	1.154717	1411.292	-1.194741	-90.56384	0.240837	1434.096	-0.033625	174.4415
0.277902	116.3335	1.102472	1366.328	-1.246873	-81.36111	0.292905	1574.803	0.018285	211.1429
0.329924	124.1581	1.05024	1335.693	-1.299214	-78.74648	0.344962	1698.052	0.070727	244.7403
0.38197	132.8134	0.99793	1315.42	-1.351537	-75.17873	0.397027	1820.218	0.122775	283.4768
0.434206	134.3848	0.945706	1280.818	-1.377812	-58.80829	0.449205	1942.121	0.174682	322.6383
0.486352	152.2299	0.89337	1249.97	-1.330484	-43.33301	0.50134	2077.444	0.226934	350.5943
0.538474	165.6702	0.841057	1214.357	-1.2782	-28.07025	0.55345	2204.814	0.279041	385.2028
0.590684	173.8747	0.788812	1170.05	-1.225952	-22.24207	0.605613	2334.895	0.33122	411.3813
0.642713	182.0535	0.736464	1137.599	-1.173623	-16.99992	0.657726	2450.744	0.38325	437.6049
0.694691	181.0167	0.684332	1096.924	-1.121474	-13.94093	0.709759	2586.364	0.435449	467.4285
0.799078	208.2514	0.579554	1012.457	-1.016848	-6.953548	0.814071	2836.995	0.539761	523.1408
0.85117	207.3562	0.527478	968.2725	-0.965128	-7.430107	0.866207	2991.169	0.591861	548.8363
0.903273	212.2764	0.475307	919.7923	-0.912882	-2.207281	0.918245	3110.296	0.643866	554.3876
0.95553	212.1089	0.423095	869.2126	-0.860664	0.388032	0.970447	3226.763	0.696081	567.6218
1.00747	220.6741	0.370757	830.8754	-0.808425	-1.917482	1.022453	3352.388	0.748168	596.2732
1.0597	227.4232	0.318466	787.1479	-0.756148	2.564746	1.074575	3511.314	0.800276	621.0157
1.111652	240.0005	0.266285	735.6409	-0.704165	3.131465	1.126628	3648.047	0.85243	637.3024
1.163859	242.8148	0.213788	692.6862	-0.651782	1.463509	1.178895	3756.619	0.904659	652.3719
1.216022	263.5257	0.161672	643.5556	-0.599838	7.059854	1.23091	3890.532	0.95666	669.3735
1.268149	256.2035	0.109609	597.2135	-0.54764	9.558568	1.283111	4013.871	1.008833	687.2895
1.320266	271.5886	0.057186	549.6864	-0.495514	14.43364	1.335103	4133.094	1.06078	707.7751
1.372388	288.925	0.004953	503.0931	-0.443343	19.97202	1.383378	4255.628	1.112896	729.2009
1.374266	303.8078	-0.047219	462.3924	-0.391143	33.75358	1.359035	4234.46	1.165126	758.6961

1.322083	299.7249	-0.099486	413.6804	-0.339157	48.17271	1.306683	4122.636	1.217341	768.2144
1.269702	291.3143	-0.15173	372.9282	-0.286933	68.83217	1.254261	3988.652	1.269357	786.6392
1.217281	282.118	-0.20404	323.5271	-0.234786	93.95454	1.201972	3876.532	1.32149	808.7154
1.165064	278.4343	-0.256203	274.068	-0.182707	120.7642	1.149755	3761.926	1.373636	828.5119
1.112648	266.2627	-0.308338	230.7398	-0.130529	144.4891	1.097398	3628.386	1.373046	855.7338
1.060424	255.9523	-0.360646	181.9698	-0.078469	172.2647	1.045249	3517.541	1.320652	847.8834
1.008044	250.8776	-0.412808	140.5092	-0.026292	199.8536	0.992915	3406.915	1.268414	813.7322
0.955745	250.6136	-0.465209	97.34197	0.025618	238.2681	0.94048	3300.198	1.215948	797.7288
0.903578	240.7153	-0.517331	49.71186	0.077911	286.3233	0.888306	3188.303	1.163814	787.3025
0.851347	225.079	-0.569589	22.05213	0.130017	335.7179	0.835962	3082.417	1.111301	765.4065
0.799015	212.7465	-0.621839	-6.36107	0.182074	375.5106	0.78384	2960.991	1.059156	749.5835
0.746666	204.7158	-0.674043	-24.0839	0.234223	412.7724	0.731566	2834.857	1.006754	716.5915
0.694523	204.1555	-0.726346	-36.25547	0.28648	452.5521	0.679284	2715.009	0.954601	692.9567
0.642286	199.4028	-0.77847	-51.18335	0.338435	492.216	0.626999	2591.857	0.902353	679.0142
0.590003	186.2202	-0.830727	-64.03112	0.390616	530.9654	0.574716	2489.906	0.850003	669.1095
0.537587	182.0664	-0.882956	-66.75523	0.442698	568.3302	0.522497	2375.261	0.797767	641.8683
0.485371	175.079	-0.935342	-71.35338	0.495106	603.4538	0.47019	2257.764	0.745404	614.1249
0.433057	162.3665	-0.987492	-86.80289	0.547083	623.7591	0.418018	2143.647	0.693085	587.7918
0.380976	153.9108	-1.039617	-106.8055	0.599121	655.4503	0.365668	2035.668	0.640899	561.8902
0.328694	143.0852	-1.091845	-123.3691	0.651376	679.2009	0.313433	1925.493	0.58856	539.962
0.276369	137.9203	-1.144242	-138.5932	0.703304	698.8364	0.261344	1811.054	0.536261	516.469
0.224248	133.4123	-1.196302	-147.6221	0.755535	715.5611	0.208852	1697.234	0.484103	495.4167
0.171914	131.1197	-1.248625	-156.5221	0.807765	745.4039	0.156644	1586.62	0.431898	471.3247
0.119689	127.3137	-1.300906	-160.7725	0.85989	776.1999	0.10451	1479.363	0.379667	445.7515
0.06735	116.8422	-1.353076	-160.4763	0.911959	810.4413	0.052195	1372.517	0.32721	427.4298
-0.037081	101.1094	-1.328496	-112.2666	1.016155	862.0256	-0.052306	1137.296	0.222875	390.7734
-0.089169	93.96742	-1.276292	-84.60042	1.068152	908.02	-0.104456	1027.404	0.170709	361.6002
-0.141516	86.77396	-1.224218	-63.9152	1.120275	948.3407	-0.156639	911.7294	0.118266	333.7473
-0.193698	79.39374	-1.171741	-47.05532	1.172483	1014.048	-0.208866	804.0207	0.066057	314.6077
-0.246033	69.59853	-1.11977	-35.50199	1.224609	1036.253	-0.261148	692.2805	0.013951	294.2895
-0.298257	59.23016	-1.067479	-24.76654	1.27679	1061.884	-0.313439	578.0996	-0.038304	268.8774
-0.350529	52.70001	-1.015379	-14.75237	1.328805	1104.24	-0.365601	467.9823	-0.090509	250.9678
-0.402752	41.79712	-0.96306	-7.108108	1.379809	1141.611	-0.417815	352.9449	-0.142748	229.0911
-0.455049	30.70747	-0.91096	-7.063028	1.365318	1139.795	-0.470152	238.5	-0.195091	211.613
-0.50723	18.75486	-0.85879	-1.833762	1.313054	1119.052	-0.522301	129.6578	-0.247441	180.012
-0.559496	13.44832	-0.806706	1.13507	1.260723	1085.403	-0.574566	44.42464	-0.299403	161.3425
-0.611701	1.952948	-0.754424	2.790146	1.208574	1078.564	-0.626731	-5.987551	-0.351725	131.1197
-0.663957	-2.883479	-0.702345	1.656709	1.156105	1049.242	-0.678872	-14.23073	-0.404025	109.2946
-0.716091	-2.47132	-0.650218	1.785508	1.10385	1002.34	-0.731297	-31.21296	-0.456141	80.26958
-0.768279	-1.672762	-0.597927	4.85738	1.051528	979.6712	-0.78344	-52.45203	-0.508463	56.46096
-0.820668	-6.451229	-0.545777	6.737855	0.999425	941.2052	-0.835786	-81.08419	-0.560681	30.07635

-0.872961	-8.589304	-0.493596	11.05908	0.9469	899.9185	-0.887953	-103.6692	-0.612915	7.117814
-0.925093	-11.13954	-0.441381	18.46506	0.894685	867.4481	-0.940199	-144.6661	-0.665104	-5.736391
-0.977413	-11.72558	-0.389225	37.33421	0.842279	835.9823	-0.992431	-195.8254	-0.717569	-12.41465
-1.029617	-12.67869	-0.337301	59.19796	0.789985	849.2229	-1.044507	-247.1134	-0.76971	-20.90255
-1.081841	-17.89508	-0.285256	87.46304	0.737713	813.3715	-1.096902	-289.9586	-0.821875	-25.84846
-1.134206	-20.89611	-0.232963	121.5885	0.685575	775.2082	-1.14909	-327.5874	-0.874065	-38.6125
-1.186333	-21.26963	-0.180824	163.326	0.633126	745.6809	-1.201514	-352.4908	-0.92629	-48.968
-1.238585	-22.30003	-0.128597	219.9464	0.581058	702.4235	-1.253588	-372.6802	-0.978484	-59.98037
-1.290737	-24.41234	-0.076613	257.4593	0.528814	675.4142	-1.306028	-392.9403	-1.030814	-74.03885
-1.34295	-21.68179	-0.02439	311.5873	0.476354	660.8727	-1.35807	-412.5887	-1.082949	-87.76889
-1.380202	-20.72223	0.027556	358.6378	0.424297	630.1604	-1.374445	-387.2345	-1.13533	-98.97446
-1.338952	-12.69801	0.079758	412.3473	0.371983	591.3209	-1.323416	-290.9568	-1.187625	-104.4806
-1.286836	-11.51306	0.131865	473.5272	0.319706	559.8745	-1.271376	-218.127	-1.239864	-103.3858
-1.234723	-5.382192	0.184034	523.759	0.267543	535.4218	-1.219093	-158.3382	-1.29197	-99.7859
-1.182225	-7.848706	0.236043	577.3332	0.215156	501.921	-1.166928	-112.434	-1.344156	-91.3946
-1.130216	-5.639792	0.288162	626.1998	0.16308	470.1268	-1.114721	-74.30933	-1.379741	-84.11098
-1.077909	-5.762151	0.340354	669.1095	0.110625	451.277	-1.062576	-46.81704	-1.337182	-60.72096
-1.025884	-2.291001	0.392288	723.669	0.058531	425.2724	-1.010416	-25.45562	-1.285137	-44.92369
-0.973723	-2.877039	0.444634	773.7528	0.006285	390.7798	-0.958181	-7.938865	-1.232977	-33.55712
		0.496666	818.6266	-0.045903	359.7391	-0.905969	0.536152	-1.180721	-21.75907
		0.548906	859.8167	-0.098038	322.5675	-0.853968	6.351456	-1.128513	-16.79384
		0.600885	902.5911	-0.150414	284.4042			-1.076554	-10.65654
		0.705145	980.2702	-0.2548	202.4361			-0.971964	-2.36828
		0.757433	1020.262	-0.307198	162.1604			-0.919912	0.677831
		0.809267	1058.638	-0.359349	125.24			-0.867723	2.287827
		0.861646	1103.074	-0.411692	84.99653			-0.815487	2.255627
				-0.463712	47.33551			-0.763181	2.667786
				-0.516067	8.82441			-0.711286	3.311784
				-0.568431	-24.71502			-0.659029	3.608024
				-0.62062	-50.33327			-0.606659	4.148982
				-0.672698	-68.12694				

B.1.2.3-Pac 1 Anodize Type III

Pac 1 Anodize Type III 1		Pac 1 Anodize Type III 2		Pac 1 Anodize Type III 3		Pac 1 Anodize Type III 4		Pac 1 Anodize Type III 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps

-1.206094	-5.253393	0.781374	1012.084	1.184874	175.7294	0.867643	589.0154	1.007958	2197.337
-1.153976	-2.5808	0.8337	1038.687	1.236892	176.2382	0.815542	555.3407	1.060071	2257.57
-1.101615	-0.919284	0.885691	1077.887	1.289225	183.8889	0.763118	550.8842	1.112151	2349.347
-1.049703	-1.627682	0.937787	1104.935	1.341274	205.8492	0.710841	520.4424	1.164502	2397.112
-0.997245	-0.970804	0.989832	1128.486	1.385815	193.2977	0.658584	507.878	1.216473	2478.996
-0.945059	0.710031	1.042	1153.738	1.353692	190.2709	0.606344	472.5612	1.268611	2578.295
-0.893101	2.751506	1.094168	1179.916	1.301322	185.7436	0.554075	446.4535	1.320785	2689.706
-0.840905	-2.40048	1.146297	1224.442	1.248875	178.9237	0.501901	430.7721	1.372815	2768.892
-0.788625	0.748671	1.198439	1247.819	1.196703	173.2114	0.449527	410.2672	1.373393	2765.737
-0.736434	4.245582	1.250329	1255.116	1.144327	169.1542	0.397291	396.6016	1.321234	2662.427
-0.684354	0.613432	1.302523	1258.896	1.091908	164.6849	0.34495	362.7916	1.268826	2624.972
-0.632178	4.93466	1.354722	1243.685	1.039683	156.3258	0.292835	350.4591	1.216516	2556.669
-0.580061	3.614464	1.385216	1237.831	0.987311	153.3312	0.240479	327.9062	1.164235	2517.16
-0.528133	2.390867	1.33939	1160.95	0.935011	152.3394	0.188211	309.0113	1.111776	2421.507
-0.475654	4.348622	1.287075	1150.949	0.88281	144.7596	0.135888	286.948	1.059629	2362.388
-0.423557	3.163665	1.234793	1179.137	0.83057	142.5313	0.083667	262.1154	1.007297	2289.39
-0.371551	15.08407	1.182434	1127.887	0.778332	134.1529	0.031511	241.9776	0.955082	2185.314
-0.319475	31.02947	1.130102	1073.824	0.726018	128.0736	-0.020648	226.7212	0.902812	2189.744
-0.267153	60.74355	1.077752	1023.296	0.673856	126.4378	-0.072926	203.5953	0.850496	2086.949
-0.215105	106.4996	1.025506	990.748	0.621488	120.2941	-0.125235	178.84	0.798221	2002.985
-0.162976	157.3626	0.973224	971.8595	0.569227	115.7796	-0.177357	159.7196	0.745915	1963.418
-0.11096	210.6148	0.920998	986.4075	0.51697	109.7196	-0.22979	138.7768	0.693851	1874.063
-0.058693	274.1903	0.868741	916.2632	0.464792	104.4066	-0.281949	120.3649	0.641439	1833.716
-0.006571	340.0456	0.816546	866.9651	0.412359	100.8518	-0.334276	97.26469	0.5891	1777.283
0.045423	401.2577	0.76421	832.3888	0.360025	93.04007	-0.38626	79.20054	0.536934	1705.013
0.097675	470.9254	0.711956	798.4372	0.307936	91.22399	-0.438455	55.70749	0.484619	1638.211
0.149807	528.0803	0.659681	809.3272	0.255795	82.06634	-0.490871	33.76002	0.432371	1555.554
0.201852	594.264	0.607233	768.7553	0.203385	75.18843	-0.543156	14.61395	0.380238	1473.296
0.253884	642.2161	0.555188	741.4305	0.151037	75.33011	-0.595404	1.611629	0.327872	1373.785
0.306212	718.6587	0.502953	710.3254	0.098905	65.78606	-0.64748	1.29607	0.27552	1302.785
0.358264	788.7772	0.450584	738.2169	0.046518	64.4723	-0.699758	-2.001201	0.223322	1212.631
0.410263	830.8303	0.398273	735.0678	-0.005519	57.92928	-0.752072	-2.722479	0.171172	1127.855
0.462621	885.5187	0.346058	690.5932	-0.057778	45.71263	-0.804179	-2.941439	0.118706	1059.817
0.514661	933.825	0.29396	665.8444	-0.110051	45.84143	-0.85636	-8.756743	0.066633	999.2037
0.566853	970.359	0.241659	574.2807	-0.162243	41.17244	-0.908735	-12.0025	0.014643	896.9625
0.618964	1026.651	0.189456	582.7428	-0.214663	35.04802	-0.961043	-13.24541	-0.037647	838.3973
0.723135	1118.936	0.0848	501.5024	-0.318983	23.63637	-1.065577	-30.62049	-0.142182	669.1288
0.775119	1167.255	0.032576	448.9329	-0.371096	18.56166	-1.11769	-33.24156	-0.194469	613.4938
0.827448	1223.051	-0.01968	405.1603	-0.423509	15.96635	-1.169902	-38.69622	-0.246834	534.7843
0.879431	1310.5	-0.071778	361.1816	-0.475524	10.76928	-1.221947	-35.96567	-0.298933	452.726
0.931511	1317.275	-0.123822	346.8591	-0.528068	5.816938	-1.274326	-27.10425	-0.351125	359.5201

0.983626	1371.705	-0.176195	292.0999	-0.580178	1.875668	-1.326581	-25.02414	-0.403529	298.5335
1.035753	1418.749	-0.228667	266.1597	-0.632539	-1.949682	-1.376181	-21.27607	-0.455681	202.4232
1.087934	1478.229	-0.280773	225.9871	-0.684624	-0.532885	-1.355391	-15.69905	-0.507734	132.4012
1.140009	1487.921	-0.333004	178.3248	-0.737116	-1.460243	-1.303068	-8.698783	-0.56	59.83551
1.192025	1541.083	-0.385205	131.5962	-0.789025	-3.141078	-1.251005	-4.171476	-0.612437	15.83111
1.244342	1568.717	-0.437461	108.6055	-0.841348	-5.626912	-1.198764	-5.047313	-0.664604	-0.391206
1.296279	1581.887	-0.489655	72.46432	-0.893681	-7.990385	-1.146724	-1.440923	-0.71683	-4.950714
1.348541	1619.509	-0.541889	33.4187	-0.94576	-8.840463	-1.094497	0.484632	-0.769256	-13.05865
1.386419	1644.728	-0.594305	5.1021	-0.998159	-15.19673	-1.042122	1.521469	-0.821301	-23.93578
1.345855	1615.298	-0.646449	-6.831188	-1.050322	-15.55093	-0.98994	-0.140046	-0.873493	-41.68438
1.293555	1598.554	-0.698736	-10.49554	-1.102459	-19.2668	-0.937752	-1.640562	-0.925836	-67.79207
1.241092	1539.055	-0.750869	-13.31625	-1.154837	-20.60631	-0.885634	-2.43912	-0.97811	-95.84463
1.188883	1480.683	-0.803144	-13.58029	-1.207014	-21.77839	-0.833398	-2.812639	-1.030311	-130.9941
1.136498	1446.261	-0.855322	-17.86932	-1.259317	-23.07927	-0.781405	0.710031	-1.082456	-162.3632
1.084134	1434.566	-0.907566	-26.38942	-1.311398	-21.23743	-0.729141	-1.054524	-1.134804	-198.6525
1.031859	1382.885	-0.959844	-36.26191	-1.36358	-19.94299	-0.676876	0.104673	-1.187042	-226.7759
0.9795	1330.29	-1.012095	-52.18799	-1.37008	-17.21244	-0.624845	0.066033	-1.239221	-250.1531
0.927319	1302.772	-1.064257	-58.66661	-1.318206	-10.8755	-0.572606	2.313587	-1.291317	-255.7623
0.875182	1265.793	-1.116512	-69.27326	-1.265868	-6.483429	-0.520526	1.006271	-1.343654	-255.8846
0.82288	1227.205	-1.168697	-72.43529	-1.213648	-7.455867	-0.468342	2.455267	-1.379744	-234.0467
0.770652	1179.633	-1.220901	-75.15941	-1.161298	-2.613	-0.416173	3.208745	-1.338007	-167.8308
0.71821	1140.568	-1.273252	-70.20706	-1.109222	-3.688477	-0.36408	6.499576	-1.285741	-114.2179
0.666114	1099.384	-1.325387	-67.32839	-1.056888	0.806631	-0.311952	13.96352	-1.23347	-74.80521
0.613794	1047.459	-1.375427	-57.52029	-1.004906	-2.986519	-0.259843	24.51865	-1.181314	-51.67279
0.561601	1000.022	-1.356011	-37.54991	-0.952617	-3.617637	-0.207712	36.87698	-1.129278	-32.38504
0.509209	956.468	-1.30378	-28.28277	-0.90064	-1.041644	-0.155527	52.25565	-1.076776	-15.96308
0.456863	928.9693	-1.251746	-15.30621	-0.848375	0.883911	-0.10349	75.46535	-1.024593	-12.96205
0.404577	876.9921	-1.199633	-10.43758	-0.796161	-1.711402	-0.051304	92.00967	-0.972583	-4.506355
0.3523	836.3816	-1.146999	-4.847674	-0.744008	-0.436286	0.000843	118.4909	-0.920325	-1.692082
0.300157	798.8751	-1.095011	-7.159628	-0.691733	-0.964364	0.052906	142.4283	-0.868311	1.35403
0.247931	747.6773	-1.042769	-2.50352	-0.639579	-3.147518	0.105144	178.4536	-0.816127	5.475619
0.195753	705.7079	-0.990787	-4.229435	-0.58757	-2.38116	0.157098	211.5615	-0.764048	5.366139
0.143287	674.9441	-0.938561	1.30251	-0.535515	-5.671992	0.209421	244.4505	-0.71175	9.294528
0.038958	576.4639	-0.833982	-1.685642	-0.43118	0.136873	0.313519	299.815	-0.60747	9.893447
-0.013253	529.291	-0.781925	1.32183	-0.379089	1.766189	0.365602	328.2476	-0.555363	12.37928
-0.065446	464.1183	-0.729838	1.025591	-0.326813	2.274947	0.417887	343.066	-0.503115	14.34348
-0.117562	426.76	-0.677564	0.941871	-0.274768	2.538987	0.469847	370.0817	-0.450915	20.38418
-0.170098	378.2991	-0.62558	3.228065	-0.222573	10.76928	0.522168	389.949	-0.398905	28.65956
-0.222261	318.7615	-0.573513	4.722141	-0.17044	18.41354	0.574178	408.6379	-0.346847	54.41949
-0.274454	279.7803	-0.521214	3.253825	-0.118226	21.41458	0.626227	427.082	-0.294569	86.61296
-0.326632	233.7923	-0.468901	-0.152926	-0.066097	25.56837	0.678354	444.8177	-0.242532	125.3559

-0.379036	182.6589	-0.416758	9.120649	-0.014141	34.0627	0.730562	462.8432	-0.190135	173.9263
-0.431134	149.7312	-0.364785	15.39319	0.038016	38.08125	0.782599	489.0604	-0.138081	229.806
-0.483418	96.51122	-0.312571	40.19357	0.090092	49.50578	0.834846	504.9929	-0.085968	298.0505
-0.53579	57.369	-0.260368	62.91383	0.142343	50.92258	0.886902	542.0872	-0.033837	369.7017
-0.587921	21.86538	-0.208322	93.03363	0.194453	62.28271	0.938959	557.3822	0.018085	443.4589
-0.640227	4.470981	-0.155954	116.8036	0.246487	66.60394	0.991056	578.7243	0.070244	519.4314
-0.692147	-1.782242	-0.10415	145.2104	0.298709	73.3466	1.043246	582.511	0.122178	576.8825
-0.744537	-4.705994	-0.051878	216.8874	0.350826	78.18303	1.095416	612.0963	0.174608	660.9693
-0.796833	-11.70626	0.000298	251.7663	0.402781	81.90534	1.147481	621.6983	0.226836	751.0905
-0.849013	-15.33197	0.052214	288.4614	0.455153	89.59468	1.199742	640.664	0.278882	843.7039
-0.901376	-24.88246	0.104252	364.3244	0.507205	95.41642	1.251628	677.6618	0.330863	954.9417
-0.95358	-39.52054	0.156533	402.2687	0.559225	95.37778	1.303813	719.966	0.383008	1062.412
-1.0058	-55.17614	0.208651	438.7706	0.611472	103.8206	1.355829	754.1172	0.435103	1156.05
-1.058101	-71.60454	0.260862	504.8126	0.663538	106.7701	1.384966	764.2216	0.487356	1244.632
-1.11028	-86.73849	0.312921	542.8343	0.71569	114.4337	1.338552	761.4073	0.539396	1339.377
-1.162514	-94.14447	0.365005	583.857	0.767793	121.2665	1.286098	720.346	0.591534	1437.908
-1.214495	-97.95694	0.41726	607.5625	0.819782	123.6944	1.233843	722.1105	0.643631	1526.568
-1.266951	-90.6862	0.46919	675.3756	0.872087	129.6771	1.181529	708.6767	0.695721	1642.726
-1.319148	-84.99326	0.521387	686.4459	0.924187	130.2567	1.129246	674.68	0.747858	1750.969
-1.371055	-76.48604	0.573475	751.2772	0.976391	136.9865	1.076898	657.8073	0.799876	1832.602
-1.362773	-54.6223	0.625621	779.7677	1.028375	143.6777	1.02457	631.178	0.852002	1923.103
-1.310403	-32.8616	0.677678	819.8051	1.08056	148.4368	0.972415	630.4631	0.904277	2013.07
-1.258345	-22.68643	0.729856	861.8582	1.132666	152.1076	0.919986	603.5504	0.956303	2146.217
-1.206071	-11.20394	0.782101	917.3064	1.184845	156.8023	0.867638	588.6097	1.008443	2269.439
-1.153884	-6.29023	0.834225	962.2382	1.236907	161.291	0.815438	574.2614	1.060583	2341.541
-1.101565	-3.772197	0.88619	995.9708	1.288887	165.0842	0.76327	568.9613	1.112565	2471.822
-1.049608	-3.997596	0.938348	1012.65	1.341349	174.5831	0.710952	535.6408	1.164833	2529.145
-0.997363	-2.284561	0.990563	1060.332	1.38585	179.7351	0.658502	516.9455	1.216892	2647.016
-0.945087	3.337544	1.042448	1078.789	1.353651	177.8224	0.606309	485.7953	1.268948	2726.569
-0.892924	1.038471	1.094587	1124.217	1.301357	174.332	0.554148	465.8507	1.320922	2796.7
-0.788716	2.113948	1.198938	1156.745	1.196742	166.2884	0.449686	422.7221	1.373438	2846.791
-0.736368	6.145377	1.251042	1164.756	1.144431	161.5808	0.397505	410.3058	1.32106	2760.083
-0.684199	-0.429846	1.303283	1161.968	1.091967	158.5733	0.345073	393.3751	1.268752	2709.954
-0.632084	2.596946	1.355184	1199.616	1.039774	151.953	0.293074	368.2785	1.216359	2636.396
-0.579864	3.150785	1.385019	1197.794	0.987447	149.6926	0.240695	351.5023	1.164051	2565.267
-0.527845	1.959388	1.338973	1163.578	0.935175	143.2011	0.188324	322.9153	1.111776	2497.672
-0.475807	2.764386	1.286598	1129.768	0.883091	140.2645	0.136118	295.9446	1.059425	2443.776
-0.423711	6.325696	1.234234	1094.329	0.830675	134.7325	0.083889	273.643	1.007239	2365.067
-0.37151	16.41071	1.181923	1074.062	0.778342	128.0027	0.031683	255.392	0.954947	2293.28
-0.31934	37.01865	1.129699	1057.833	0.726355	123.5334	-0.020568	242.087	0.902643	2234.2
-0.267222	61.29739	1.077347	986.5685	0.673774	118.0272	-0.072648	209.5394	0.850477	2169.781

-0.2151	105.7333	1.025101	935.7312	0.621449	116.9646	-0.124943	189.8717	0.797979	2091.876
-0.162981	167.5185	0.972826	927.3915	0.569229	112.7207	-0.17723	173.0504	0.745844	2030.49
-0.110758	229.9799	0.920599	885.8149	0.516982	105.978	-0.229538	150.4396	0.693538	1987.426
-0.058764	295.3135	0.868251	844.3801	0.464556	101.6761	-0.281756	123.3917	0.64132	1906.862
-0.006546	350.3432	0.816185	820.082	0.41263	93.02075	-0.33407	102.977	0.589022	1825.538
0.045471	419.0127	0.763636	802.8228	0.360239	89.0022	-0.386277	77.41023	0.536748	1726.445
0.097491	477.8226	0.711461	761.2592	0.307938	82.30461	-0.438306	53.51145	0.484545	1677.566
0.149878	532.4852	0.659184	733.2517	0.25567	80.71394	-0.490687	35.7693	0.432237	1591.302
0.20198	589.9427	0.606985	759.9648	0.203381	74.93083	-0.543029	14.93595	0.380058	1507.956
0.254191	642.0744	0.554762	742.8151	0.151194	69.80461	-0.595228	2.822346	0.327789	1438.114
0.3063	708.0327	0.502353	731.6546	0.098884	63.64798	-0.64737	-0.075647	0.275618	1340.832
0.358461	759.2499	0.45015	705.7336	0.046542	58.41228	-0.699782	-2.70316	0.223358	1284.044
0.410349	806.9895	0.397998	667.0487	-0.005439	53.87853	-0.751813	-0.990124	0.170847	1177.392
0.46264	864.6596	0.345645	659.2048	-0.05758	46.92335	-0.804097	-6.41903	0.118838	1092.448
0.514743	905.3731	0.293345	622.1555	-0.10989	42.09336	-0.856493	-7.294867	0.06648	1009.475
0.566897	946.808	0.241124	580.1926	-0.162306	35.00294	-0.908623	-13.88297	0.014339	938.2557
0.618878	1000.44	0.188791	558.0069	-0.214405	34.02406	-0.960743	-20.59343	-0.03785	861.2271
0.67114	1043.813	0.13669	520.0238	-0.266538	29.2456	-1.013091	-27.46489	-0.090199	773.347
0.723124	1083.419	0.084342	466.25	-0.318844	25.11113	-1.065213	-37.48551	-0.142379	722.542
0.775366	1130.985	0.031999	430.5016	-0.371273	17.24791	-1.117464	-47.10684	-0.19468	612.4312
0.827445	1175.782	-0.020009	396.9558	-0.423222	15.92127	-1.169876	-51.43451	-0.246814	540.2067
0.879681	1216.283	-0.072219	365.8378	-0.475725	10.15749	-1.222131	-60.32813	-0.29894	447.1554
0.931819	1244.908	-0.124458	322.2069	-0.527948	7.484893	-1.274328	-57.12101	-0.351341	385.7953
0.983939	1299.951	-0.176785	290.5157	-0.58025	2.577626	-1.326606	-55.89742	-0.403544	288.0814
1.035855	1336.691	-0.229277	255.2117	-0.632361	-3.958956	-1.376145	-52.22019	-0.455696	202.2493
1.087961	1372.929	-0.281252	215.857	-0.684435	-2.65164	-1.355375	-36.39715	-0.507999	129.2843
1.140121	1372.781	-0.333487	173.7588	-0.736778	-2.748239	-1.303304	-21.24387	-0.560284	61.63871
1.24434	1428.545	-0.438037	98.68793	-0.841313	-4.615834			-0.664706	-0.771165
1.296436	1476.909	-0.490165	62.84299	-0.893498	-9.96102			-0.717019	-4.107076
1.348549	1538.25	-0.542416	33.12891	-0.945722	-9.072302			-0.769153	-14.73949
1.386214	1563.43	-0.594774	0.342952	-0.997957	-17.98524			-0.821435	-30.56253
1.345541	1543.073	-0.64688	-7.256227	-1.050211	-15.60245			-0.873605	-54.68026
1.293127	1529.846	-0.69924	-15.53161	-1.102518	-18.75804			-0.925848	-84.49738
1.240984	1443.241	-0.751542	-13.37421	-1.154602	-23.88426			-0.978054	-103.4696
1.188623	1446.152	-0.803723	-15.93732	-1.206883	-26.38942			-1.030349	-139.585
1.136284	1384.392	-0.855995	-24.52182	-1.25924	-24.78586			-1.082669	-173.8071
1.083867	1351.96	-0.908006	-32.24336	-1.311388	-23.74902			-1.134884	-205.6657
1.031673	1316.985	-0.96022	-43.56485	-1.36356	-22.86031			-1.187044	-237.1185
0.979518	1265.207	-1.0126	-53.93966	-1.370169	-19.21528			-1.23935	-253.6306
0.92706	1220.385	-1.064854	-63.73488	-1.318363	-8.460504			-1.291617	-265.5575
0.874925	1219.528	-1.116967	-73.50433	-1.266071	-8.112745			-1.34371	-269.3828

0.82251	1187.122	-1.169275	-86.13314	-1.213695	-5.073073			-1.380126	-243.3975
0.77019	1143.06	-1.221433	-86.15246	-1.161661	-8.415424			-1.338099	-173.2275
0.718087	1079.092	-1.273736	-84.34926	-1.109264	-2.735359			-1.285787	-120.2844
0.665772	1033.155	-1.32598	-77.76116	-1.057258	-0.726085			-1.233518	-79.89279
0.613324	973.8366	-1.375776	-69.54374	-1.005023	-1.054524			-1.181327	-56.16146
0.561235	940.5612	-1.355381	-47.0682	-0.952758	-1.048084			-1.129222	-35.07695
0.508876	911.826	-1.303257	-34.4072	-0.900622	-1.292803			-1.077073	-21.05711
0.45666	859.9069	-1.251247	-24.29642	-0.848523	-0.623045			-1.024884	-11.5839
0.404628	821.4666	-1.198915	-14.53985	-0.796306	-1.118924			-0.972724	-2.4198
0.352003	792.1196	-1.146706	-8.074105	-0.744171	1.894988			-0.920583	0.445992
0.299878	742.6734	-1.094501	-5.852311	-0.691871	2.068868			-0.868276	4.258462
0.247601	690.0523	-1.042464	-4.319595	-0.639761	-1.273483			-0.816095	4.599781
0.195499	649.7187	-0.990242	-4.094196	-0.587659	-1.975441			-0.763891	7.465573
0.143176	605.3214	-0.938096	-3.656277	-0.535594	0.388032			-0.711762	8.161091
0.090903	581.0813	-0.885956	-1.640562	-0.4834	0.497512			-0.65969	9.848367
0.03846	529.0656	-0.833738	0.156193	-0.431244	-1.936802			-0.607494	13.15208
-0.013452	487.811	-0.781571	-2.65808	-0.379047	1.637389			-0.555308	11.5936
-0.065695	432.0086	-0.72955	2.165467	-0.326972	1.11575			-0.503124	11.36176
-0.117961	389.6142	-0.677075	-0.436286	-0.274821	6.312816			-0.451125	17.99495
-0.170335	366.2499	-0.625026	2.320027	-0.222596	10.04157			-0.398856	28.45992
-0.222328	314.9297	-0.572924	0.587672	-0.170379	13.11344			-0.346785	51.1995
-0.274648	264.8717	-0.520944	4.483861	-0.118342	18.32982			-0.294588	80.94578
-0.326923	231.4804	-0.468448	5.12786	-0.066296	22.39345			-0.242453	115.1228
-0.379222	186.6388	-0.416257	6.943935	-0.014177	27.22988			-0.190434	159.52
-0.483727	92.38963	-0.312078	36.03978	0.090026	41.01788			-0.086175	274.3385
-0.535745	54.32933	-0.260096	57.90996	0.142177	47.59955			-0.033921	342.6345
-0.588116	19.84322	-0.207801	74.85999	0.194321	54.92181			0.018077	422.1554
-0.640145	2.448827	-0.15574	98.90689	0.246523	62.01223			0.070065	527.9643
-0.692731	-1.666322	-0.103492	122.1359	0.298644	66.48158			0.122247	573.3276
-0.744876	-3.269878	-0.051417	176.2962	0.350635	73.46896			0.174373	659.1339
		0.000643	224.1388	0.402969	79.18122			0.226666	730.7723
		0.052641	253.1058	0.454842	83.54109			0.278673	809.836
		0.105017	292.0033	0.507054	84.98365			0.330834	891.4177
		0.156942	341.5912	0.559247	91.88087			0.382926	1013.178
		0.209114	380.9266	0.611391	96.36954			0.435128	1117.21
		0.261279	429.8254	0.663506	101.7083			0.487163	1218.827
		0.3134	470.1075	0.715613	107.7425			0.539308	1323.508
		0.365475	519.2897	0.767648	111.7804			0.591426	1429.137
		0.417605	569.0321	0.819976	118.0401			0.643508	1517.255
		0.46952	594.0643	0.872081	120.6354			0.695618	1614.209
		0.521837	643.1821	0.924113	127.758			0.747746	1719.96

		0.573986	687.9593	0.976182	132.1565			0.799753	1787.503
		0.625904	750.6525	1.028191	138.8026			0.85205	1899.765
		0.678329	780.9849	1.080404	143.5167			0.904218	1982.325
		0.730315	833.87	1.132639	146.5306			0.956186	2066.058
		0.782499	884.0504	1.184845	155.0635			1.008385	2140.704
		0.834449	899.2165	1.236794	158.5669			1.060514	2255.078
		0.886714	943.2531	1.289003	162.3987			1.112577	2344.323
		0.938848	973.5146	1.341021	169.9013			1.16472	2426.517
		0.990821	996.1705	1.385629	172.5223			1.216769	2546.056
		1.042915	1012.489	1.353749	171.9492				
		1.095183	1037.238	1.301348	166.3915				
		1.147248	1058.097						
		1.199461	1064.409						
		1.25148	1094.136						
		1.303605	1142.545						
		1.355654	1168.859						
		1.38506	1167.564						
		1.338555	1138.99						
		1.286237	1111.639						
		1.233974	1102.772						
		1.181729	1093.099						
		1.077119	1017.873						
		1.024739	1000.537						
		0.972412	994.1677						
		0.920113	949.6674						
		0.867995	904.6454						
		0.815675	885.5444						
		0.763229	856.5001						
		0.711196	836.871						
		0.658686	811.3623						
		0.606583	785.8406						
		0.554406	739.3117						
		0.50196	718.678						
		0.449751	694.4637						
		0.397597	670.874						
		0.345243	620.8675						
		0.293075	573.7011						
		0.240881	572.2585						
		0.188573	541.4561						
		0.136283	491.5269						
		0.084171	473.0442						

		0.031786	438.8929						
		-0.020291	389.1312						
		-0.072626	372.4774						
		-0.12485	322.9603						
		-0.177111	301.8887						
		-0.229421	258.0131						
		-0.281695	213.7511						
		-0.333768	174.0229						
		-0.386098	138.3969						
		-0.438344	95.74486						
		-0.490418	64.81362						
		-0.542949	28.17656						

B.1.2.4-Pac 1 Natural Oxide

Pac 1 Natural Oxide 1		Pac 1 Natural Oxide 2		Pac 1 Natural Oxide 3		Pac 1 Natural Oxide 4		Pac 1 Natural Oxide 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
0.88395	18318.95	0.038162	7905.305	1.056519	26232.1	0.987453	22845.06	0.101362	11358.76
0.936038	19038.93	0.084155	8731.775	1.108504	27115.06	1.039522	23686.76	0.049242	10489.46
0.988045	19762.16	0.130579	9530.67	1.160737	27993.85	1.091648	24510.07	-0.002954	9612.627
1.040202	20492.07	0.175598	10304.24	1.212807	28874.68	1.143911	25343.04	-0.055164	8749.578
1.092587	21222.73	0.222397	11040.59	1.264909	29741.82	1.196006	26170.41	-0.107418	7886.515
1.144429	21951.78	0.268553	11797.54	1.316999	30626.68	1.248028	27004.61	-0.159765	7028.759
1.196509	22673.6	0.314979	12538.93	1.369161	31521.28	1.300175	27782.73	-0.212026	6162.484
1.248705	23402.58	0.361624	13276.34	1.376323	31704.76	1.352362	28587.62	-0.264075	5318.066
1.300724	24128.99	0.408575	13996.96	1.324397	30911.01	1.385531	29153.45	-0.316293	4470.911
1.352972	24854.21	0.456987	14772.1	1.271906	30096.94	1.341548	28586.25	-0.368669	3636.636
1.385322	25318.74	0.503549	15525.71	1.219717	29275.5	1.28924	27830	-0.420853	2803.031
1.340807	24804	0.547849	16193.12	1.167447	28428.52	1.236915	27082.9	-0.472987	2010.326
1.288341	24167.48	0.579248	16613.31	1.11496	27584.99	1.184671	26254.14	-0.525192	1289.331
1.235968	23520.46	0.626402	17350.66	1.062638	26743.16	1.132203	25594.5	-0.577406	758.8184
1.183909	22859.54	0.683984	18317.25	1.010409	25892.12	1.079977	24824.91	-0.629664	495.4617
1.131434	22192.48	0.742064	19286.66	0.958182	25045.01	1.027581	24055.55	-0.681982	373.8749
1.079188	21529.04	0.796482	20125.44	0.905942	24176.4	0.975389	23285.44	-0.734086	261.0979
1.02683	20850.3	0.84674	20915.31	0.85361	23312.31	0.92305	22512.71	-0.786391	90.99859
0.974614	20170.03	0.891703	21579.85	0.8014	22441.59	0.870982	21744.67	-0.838608	-129.0749

0.922227	19491.82	0.935057	22262.83	0.748941	21584	0.818615	20966.93	-0.890858	-412.2088
0.869982	18803.77	0.978513	22938.09	0.696968	20728.78	0.766256	20197.83	-0.94298	-769.4088
0.817787	18126.46	1.024079	23649.41	0.644624	19872.45	0.714018	19435.61	-0.995212	-1186.011
0.76535	17454.02	1.073561	24456.79	0.592334	19016.05	0.661587	18680.32	-1.047456	-1636.204
0.713297	16757.56	1.122524	25236.64	0.540029	18170.89	0.609547	17933.53	-1.099708	-2098.524
0.661204	16063.38	1.172145	25977.85	0.487746	17318.63	0.557196	17144.66	-1.151778	-2561.932
0.60881	15378.32	1.219983	26769.16	0.435529	16465.38	0.505079	16361.94	-1.204256	-2988.407
0.556383	14686.95	1.268852	27526.9	0.383275	15611.79	0.452677	15571.68	-1.25642	-3377.517
0.50425	14009.74	1.314984	28281.09	0.331144	14766.81	0.400521	14776.72	-1.308542	-3726.074
0.451928	13325.54	1.361818	29025.18	0.278829	13912.55	0.348174	13986.5	-1.360598	-4039.643
0.399585	12638.45	1.399924	29638.14	0.226385	13059.91	0.29597	13195.42	-1.372188	-3854.243
0.347391	11945.96	1.362164	29106.99	0.174079	12213.1	0.243809	12410.26	-1.320745	-3063.175
0.295298	11262.31	1.309257	28364.22	0.122027	11363.89	0.191484	11620.16	-1.268656	-2412.299
0.242752	10583.82	1.256429	27553.11	0.069764	10519.38	0.139178	10837.66	-1.216525	-1852.369
0.19049	9904.694	1.198635	26674.32	0.017636	9674.838	0.086987	10059.58	-1.164236	-1379.365
0.138344	9223.4	1.147241	25893.84	-0.034671	8829.137	0.034735	9268.171	-1.11196	-980.2667
0.08623	8544.779	1.100371	25234.09	-0.086899	7984.667	-0.017448	8492.28	-1.059655	-648.0667
-0.01824	7198.827	0.999119	23746.72	-0.191336	6310.082	-0.121926	6938.683	-0.955482	-186.1203
-0.070506	6518.821	0.94809	22993.54	-0.243705	5474.229	-0.174235	6157.853	-0.903386	-45.36805
-0.122547	5851.664	0.896995	22198.58	-0.295771	4647.991	-0.226239	5381.384	-0.851237	51.6503
-0.174882	5179.29	0.84498	21403.53	-0.347987	3822.925	-0.278678	4623.062	-0.79895	113.4548
-0.227159	4526.52	0.791006	20618.53	-0.400104	3003.327	-0.33083	3858.036	-0.746602	158.2578
-0.279258	3868.669	0.738907	19789.78	-0.452335	2212.561	-0.382931	3105.021	-0.694596	198.5077
-0.331644	3224.605	0.685773	19021.99	-0.504668	1464.724	-0.435215	2380.304	-0.642475	226.6633
-0.383855	2582.326	0.632022	18222.02	-0.556656	834.6428	-0.487383	1698.451	-0.590363	260.3379
-0.436149	1966.019	0.58187	17428.05	-0.609028	436.626	-0.539788	1134.714	-0.538294	299.5381
-0.488259	1391.837	0.533326	16694.75	-0.66131	259.7712	-0.592066	774.1263	-0.485979	372.0073
-0.540537	927.9968	0.482437	15924.14	-0.713443	166.3335	-0.644142	598.9716	-0.433898	519.5215
-0.5927	637.8176	0.429238	15136.61	-0.7658	80.42414	-0.696302	479.175	-0.381854	878.7245
-0.644932	505.9525	0.375886	14321.07	-0.817942	-28.62409	-0.748577	308.0647	-0.329693	1537.966
-0.697224	423.8684	0.323305	13504.13	-0.870086	-163.5031	-0.800709	74.12584	-0.277578	2331.263
-0.749437	305.128	0.272233	12721.74	-0.922279	-342.3028	-0.852964	-211.32	-0.225577	3178.579
-0.801734	142.0548	0.217884	11942.07	-0.974557	-570.9028	-0.905124	-561.9512	-0.173467	4067.664
-0.853959	-69.13158	0.166311	11127.9	-1.026792	-836.8418	-0.957382	-960.7793	-0.121258	4995.364
-0.905938	-326.2157	0.113058	10361	-1.079101	-1111.539	-1.009804	-1403.914	-0.069051	5967.564
-0.958531	-623.8459	0.058939	9511.983	-1.13133	-1353.85	-1.061795	-1852.491	-0.016974	6979.964
-1.010658	-954.423	0.006305	8732.48	-1.183512	-1530.982	-1.114129	-2310.767	0.034932	7995.937
-1.06265	-1296.006	-0.045041	7969.752	-1.235945	-1657.501	-1.16618	-2749.348	0.087085	9043.937
-1.11495	-1644.274	-0.097912	7162.647	-1.2881	-1729.269	-1.218684	-3152.485	0.139175	10075.7
-1.167368	-1967.767	-0.149923	6387.851	-1.340276	-1754.597	-1.271009	-3507.92	0.191434	11088.04
-1.219386	-2242.619	-0.203174	5624.925	-1.380095	-1643.173	-1.322987	-3829.629	0.243536	12076.76

-1.271828	-2472.339	-0.254707	4852.66	-1.341151	-1094.183	-1.373817	-4099.483	0.295778	13042.44
-1.324029	-2673.221	-0.307846	4094.532	-1.289188	-705.2344	-1.358405	-3640.583	0.347747	13987.86
-1.374489	-2816.968	-0.36053	3355.112	-1.236988	-454.1073	-1.306289	-2914.94	0.399969	14928.24
-1.357582	-2384.285	-0.413595	2619.034	-1.184588	-276.7115	-1.254107	-2311.501	0.451886	15880.94
-1.305314	-1815.551	-0.465811	1918.557	-1.132551	-156.6381	-1.201878	-1791.176	0.50406	16796.18
-1.253147	-1360.271	-0.518608	1294.632	-1.080185	-66.22715	-1.149614	-1340.094	0.556161	17720.32
-1.201032	-996.0189	-0.570481	833.4579	-1.027957	-5.601152	-1.097599	-956.5289	0.608412	18641.37
-1.148894	-700.5654	-0.624033	597.22	-0.975967	39.79429	-1.045176	-637.1767	0.660436	19550.7
-1.096611	-463.0009	-0.676754	497.6256	-0.923768	71.98776	-0.993146	-372.3839	0.712548	20451.83
-1.044369	-276.8081	-0.727568	380.6111	-0.871603	100.1047	-0.940968	-164.1535	0.764649	21332.78
-0.992151	-134.8838	-0.782438	204.8963	-0.819422	116.9131	-0.888914	-9.651901	0.816873	22200.55
-0.940034	-30.18901	-0.835136	31.49963	-0.767182	134.7583	-0.836749	94.3667	0.868972	23103.77
-0.887838	47.37415	-0.887576	-195.9927	-0.715076	148.7781	-0.784405	175.298	0.921097	24048.66
-0.83577	105.2503	-0.940315	-533.9823	-0.662839	169.6501	-0.732283	232.3047	0.973144	24985.24
-0.731076	180.7011	-1.045016	-1253.464	-0.558694	219.0963	-0.627991	321.4341	1.077441	26793.14
-0.67913	215.1293	-1.098869	-1644.531	-0.506433	253.4858	-0.57584	362.7144	1.129493	27710.91
-0.627065	248.6558	-1.150901	-2042.477	-0.454346	356.3323	-0.523789	419.6889	1.181691	28604.77
-0.574985	280.8171	-1.203819	-2442.625	-0.402101	612.6823	-0.471559	506.5256	1.2338	29539.32
-0.522726	322.6255	-1.257709	-2809.047	-0.35005	1160.944	-0.419425	679.6517	1.285763	30398.82
-0.470501	399.609	-1.309928	-3140.925	-0.297937	1926.381	-0.367401	1020.514	1.338074	31254.88
-0.418338	566.4046	-1.362697	-3433.976	-0.245858	2780.034	-0.315043	1629.981	1.384398	32017.12
-0.366378	873.4502	-1.358872	-3128.277	-0.193816	3691.537	-0.263142	2366.889	1.355471	31623.01
-0.314327	1395.894	-1.308661	-2490.043	-0.141565	4658.578	-0.210964	3140.589	1.303167	30838.05
-0.262275	2012.683	-1.258508	-1936.101	-0.089475	5681.597	-0.159038	3929.436	1.250937	30086.18
-0.20988	2662.678	-1.207419	-1494.782	-0.037465	6735.006	-0.106726	4755.964	1.198656	29246.43
-0.157835	3335.991	-1.156266	-1090.661	0.01456	7765.495	-0.054621	5616.54	1.146241	28470.92
-0.105682	4030.293	-1.104054	-755.7753	0.066567	8748.386	-0.002467	6502.612	1.093905	27673.89
-0.053617	4759.654	-1.052261	-470.1106	0.118883	9697.191	0.049489	7408.178	1.041543	26854.81
-0.00165	5515.046	-0.999757	-267.9725	0.17093	10629.87	0.10168	8329.355	0.989378	26016.99
0.050509	6284.154	-0.947956	-120.542	0.223112	11540.43	0.15377	9246.256	0.937147	25174.16
0.10254	7066.517	-0.895907	-12.18281	0.275199	12439.77	0.20588	10149.89	0.884858	24343.64
0.154793	7853.491	-0.843642	60.36359	0.327313	13332.41	0.257949	11041.79	0.832606	23449.36
0.206762	8640.838	-0.791251	104.3358	0.379343	14222.31	0.310122	11918.28	0.780187	22559.75
0.258961	9421.134	-0.739281	138.3453	0.431488	15109.81	0.36222	12775.84	0.727991	21676.08
0.311088	10187.98	-0.687341	163.8026	0.483764	16004.05	0.414326	13622.88	0.67573	20828.74
0.363289	10938.42	-0.634941	198.1084	0.535744	16882.43	0.466292	14461.54	0.623353	19959.99
0.415296	11680.92	-0.582766	219.6179	0.587939	17767.55	0.518584	15293.64	0.571192	19152.89
0.46735	12410.43	-0.530613	266.9776	0.640084	18655.35	0.570718	16114.6	0.518831	18282.85
0.519671	13134.8	-0.478529	341.5333	0.692115	19528.34	0.622934	16931.92	0.466613	17384.88
0.571716	13851.4	-0.426379	508.9857	0.744125	20411.74	0.675025	17746.75	0.414349	16530.81
0.623839	14575.12	-0.374326	893.1307	0.796498	21289.19	0.72709	18569.86	0.36206	15662.4

0.675858	15284.64	-0.322189	1493.588	0.848573	22167.42	0.779164	19380.75	0.30987	14770.75
0.727992	15989.57	-0.270044	2200.274	0.900721	23055.73	0.831377	20191	0.257706	13907.22
0.780048	16705.72	-0.217928	2972.808	0.952757	23941.16	0.883412	20990.45	0.205419	13063.33
0.832366	17416.16	-0.165743	3765.152	1.004896	24817.06	0.9356	21786.58	0.153198	12198.23
0.884351	18128.73	-0.113737	4583.185	1.057048	25687.92	0.987552	22609.01	0.100929	11317.25
0.936492	18839.58	-0.061635	5434.951	1.109065	26564.89	1.03982	23451.81	0.048657	10468.1
0.988658	19540.87	-0.009484	6317.733	1.161253	27456.47	1.091943	24290.11	-0.003515	9600.127
1.040741	20252.6	0.042491	7216.163	1.213262	28351.24	1.144104	25109.27	-0.055766	8726.516
1.092878	20963.17	0.094568	8114.504	1.265439	29246.25	1.196052	25916.47	-0.108048	7874.627
1.145111	21690.48	0.146963	9015.401	1.317588	30132.71	1.248281	26692.32	-0.16017	7020.606
1.197136	22410.42	0.198925	9895.653			1.300341	27519.38	-0.212405	6171.352
1.301315	23829.75	0.303219	11590.54			1.385459	28846.97	-0.316722	4476.404
1.353482	24549.36	0.355192	12421.76			1.341349	28257.31		
1.385063	25002.75	0.40747	13246.76			1.288895	27557.13		
1.340183	24480.99	0.459547	14065.59						
1.287919	23845.8	0.511516	14889.78						
1.2355	23198.84	0.563874	15708.26						
1.18326	22553.74	0.615871	16517.37						
		0.668009	17333.51						
		0.720067	18156.99						
		0.772249	18964.69						
		0.824539	19775.89						
		0.876466	20577.07						
		0.928562	21387.48						
		0.980731	22184.52						
		1.03283	22994.34						
		1.084989	23813.64						
		1.137137	24611.07						
		1.189328	25427.37						
		1.241391	26248.19						
		1.293551	27039.38						
		1.345501	27852.18						
		1.385906	28485.5						
		1.347873	28011.56						
		1.295694	27296.29						
		1.243279	26557.22						
		1.191029	25825.4						
		1.138688	25098.01						
		1.086395	24364.06						
		1.034082	23631.73						
		0.981864	22879						

		0.929601	22109.74						
		0.877259	21351.01						
		0.825129	20595.22						
		0.772762	19824.01						
		0.720468	19078.76						
		0.668104	18336.52						
		0.615887	17588.25						
		0.563712	16825.76						
		0.459123	15254.95						
		0.406892	14488.87						
		0.354631	13715.66						
		0.302284	12934.87						
		0.250176	12160.29						
		0.19796	11385.84						
		0.14559	10605.82						
		0.093392	9838.639						
		0.041238	9066.265						
		-0.011189	8303.383						
		-0.063328	7535.297						
		-0.115497	6777.026						
		-0.167634	6018.576						
		-0.219963	5265.174						
		-0.272212	4523.403						
		-0.324379	3786.687						
		-0.376582	3065.879						
		-0.42878	2354.434						
		-0.480854	1677.418						
		-0.533391	1088.52						
		-0.585568	692.6605						

B.1.3 Pac 2

B.1.3.1-Pac 2 Alodine

Pac 2 Alodine 1		Pac 2 Alodine 2		Pac 2 Alodine 3		Pac 2 Alodine 4		Pac 2 Alodine 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-1.323678	-1158.364	-0.503641	1481.578	0.03881	7160.599	-1.215559	-18.77736	-1.230196	-16.92908

-1.374435	-1124.909	-0.555883	877.005	-0.013706	6574.682	-1.163081	-2.934998	-1.177668	-13.30337
-1.358048	-868.3205	-0.607655	498.7977	-0.065842	5987.413	-1.111367	-5.491671	-1.125474	-6.663748
-1.305744	-589.9845	-0.660059	311.5551	-0.117737	5403.872	-1.059048	-4.016915	-1.073482	-6.972868
-1.25351	-400.5395	-0.712312	175.3495	-0.170026	4817.743	-1.007066	-6.554269	-1.02159	-2.104241
-1.201537	-258.6345	-0.764652	-19.77555	-0.222338	4224.954	-0.955065	4.239143	-0.969214	3.955783
-1.149057	-154.8671	-0.816567	-259.3171	-0.274476	3639.836	-0.902329	5.011941	-0.917244	-0.326805
-1.097144	-84.04658	-0.868978	-535.3219	-0.326862	3058.254	-0.850388	-0.384765	-0.864657	4.567582
-1.045278	-36.31987	-0.921069	-870.1043	-0.379184	2468.094	-0.798287	1.27675	-0.81257	5.1665
-0.992655	4.683501	-0.973436	-1249.374	-0.431284	1901.175	-0.746036	7.265934	-0.760571	1.26387
-0.940568	25.22705	-1.025753	-1653.831	-0.483403	1334.411	-0.693914	9.03693	-0.708388	8.476651
-0.888554	42.1964	-1.078004	-2039.405	-0.535636	821.8272	-0.641626	0.845272	-0.656304	6.274177
-0.836309	54.03953	-1.130016	-2415.094	-0.587838	404.9156	-0.589436	4.889581	-0.603888	8.341412
-0.783943	68.47797	-1.182531	-2765.906	-0.639952	175.0275	-0.537285	3.395505	-0.552017	12.23116
-0.732022	78.8721	-1.234716	-3071.534	-0.692263	86.21368	-0.485496	8.727811	-0.499615	8.495971
-0.679644	85.76289	-1.286806	-3324.258	-0.744623	8.154652	-0.433042	13.90556	-0.447672	17.51195
-0.62771	96.42106	-1.339107	-3519.995	-0.796777	-90.02933	-0.381018	55.63665	-0.395478	40.38677
-0.575536	105.4628	-1.380075	-3552.266	-0.84903	-213.7156	-0.328876	142.5185	-0.343438	143.7871
-0.523163	112.2248	-1.342376	-2914.56	-0.90146	-374.8311	-0.276716	277.6937	-0.291098	302.0433
-0.471152	129.2779	-1.290852	-2294.461	-0.953675	-571.3407	-0.224529	476.7021	-0.239048	563.6805
-0.419029	175.7616	-1.238176	-1783.854	-1.00592	-787.196	-0.172643	710.364	-0.186738	919.2384
-0.366907	293.433	-1.186156	-1354.758	-1.058152	-1002.208	-0.1203	970.7326	-0.134901	1291.476
-0.314868	527.9515	-1.133849	-990.9248	-1.110283	-1202.787	-0.068454	1211.607	-0.082833	1658.523
-0.262577	815.0653	-1.081594	-681.3292	-1.162611	-1384.678	-0.016152	1445.366	-0.030769	2025.654
-0.210627	1151.838	-1.029607	-432.8489	-1.214711	-1540.906	0.035912	1704.633	0.021142	2367.842
-0.158443	1520.366	-0.977327	-225.8228	-1.267112	-1658.042	0.088084	1964.467	0.073569	2750.809
-0.106182	1938.669	-0.925285	-74.26425	-1.319082	-1717.612	0.140383	2229.898	0.125544	3154.081
-0.054011	2372.627	-0.87335	35.34426	-1.370842	-1768.25	0.192527	2477.85	0.177691	3555.743
-0.002019	2841.104	-0.82072	116.5782	-1.362593	-1504.108	0.244707	2751.633	0.229852	3959.865
0.049537	3333.312	-0.768616	170.5775	-1.310747	-1153.56	0.29634	3008.338	0.282115	4388.736
0.102004	3825.366	-0.716565	212.4052	-1.258134	-874.4642	0.348526	3245.22	0.333923	4746.304
0.154121	4320.382	-0.664299	253.9495	-1.205925	-657.9456	0.400631	3407.353	0.386471	5135.949
0.20641	4813.512	-0.612292	277.9513	-1.153735	-473.2018	0.4531	3608.538	0.438314	5533.741
0.258415	5280.894	-0.560196	298.1406	-1.101454	-323.7556	0.504863	3878.702	0.490353	5952.199
0.310705	5758.284	-0.508135	334.475	-1.049493	-205.6399	0.556896	4124.446	0.542557	6412.22
0.362519	6239.068	-0.455846	409.3398	-0.997078	-105.0796	0.609446	4372.553	0.594736	6784.555
0.414774	6717.824	-0.403518	558.7024	-0.945084	-49.129	0.661278	4646.613	0.646819	7184.298
0.519011	7652.756	-0.299361	1569.368	-0.840588	32.85843	0.765421	5122.696	0.751076	7975.484
0.570995	8153.872	-0.247403	2269.433	-0.788616	51.70826	0.817727	5383.103	0.803012	8381.345
0.623041	8616.064	-0.195287	3028.038	-0.73625	69.05757	0.869949	5682.421	0.85521	8774.488
0.67533	9117.347	-0.142981	3834.91	-0.684115	83.57329	0.921764	5983.162	0.907103	9168.97
0.727525	9594.022	-0.090888	4717.169	-0.63232	90.26443	0.973807	6132.576	0.959104	9531.471

0.77926	10066.22	-0.038686	5619.206	-0.579795	99.28685	1.026131	6262.748	1.011648	9953.284
0.831761	10542.76	0.013312	6539.526	-0.527839	106.081	1.078301	6486.093	1.063593	10365.77
0.883941	10992.44	0.065128	7438.704	-0.475542	127.011	1.130272	6722.035	1.115917	10781.07
0.936067	11490.76	0.117272	8360.048	-0.423442	226.747	1.182654	7074.606	1.168035	11235.7
0.987883	11894.37	0.169573	9264.159	-0.371433	535.4605	1.234302	7414.431	1.220104	11835.75
1.040015	12366.37	0.221684	10173.77	-0.319112	1004.246	1.28641	7661.482	1.27217	12354.99
1.092267	12834.17	0.273661	11055.84	-0.267283	1537.264	1.338514	7919.894	1.324205	12822.27
1.144434	13284.78	0.326048	11954.02	-0.215131	2143.222	1.384837	8346.93	1.37615	13166.64
1.196693	13722.84	0.377982	12825.43	-0.162908	2801.781	1.355159	8383.316	1.369468	13277.84
1.248653	14200.07	0.430252	13688.14	-0.110966	3480.872	1.302761	8255.52	1.316654	13061.33
1.30075	14637.14	0.482475	14540.83	-0.058676	4148.911	1.250478	8193.065	1.265034	12823.93
1.35271	15227.44	0.534246	15382.98	-0.006392	4831.737	1.198089	8092.428	1.212345	12701.1
1.385352	15529.48	0.586712	16237.27	0.045184	5516.07	1.14554	7862.327	1.160145	12479.37
1.341035	15238.57	0.638616	17078.09	0.097032	6191.161	1.093575	7688.363	1.10802	12306.84
1.288597	14936.2	0.690825	17934.33	0.149741	6835.141	1.041378	7582.264	1.055352	12017.6
1.236275	14536.59	0.743008	18761.6	0.201673	7485.844	0.989026	7401.912	1.003033	11731.12
1.184137	14122.76	0.794984	19606.01	0.253763	8160.537	0.936543	7241.028	0.950941	11534.83
1.131609	13732.81	0.847152	20462.03	0.305782	8821.957	0.884554	7049.47	0.898878	11283.52
1.079548	13317.66	0.899147	21286.11	0.357945	9450.23	0.832216	6802.001	0.846254	10949.59
1.026996	13000.39	0.951474	22120.15	0.410236	10061.91	0.779706	6572.621	0.793975	10659.87
0.97512	12581.91	1.003391	22949.51	0.462372	10706.89	0.72768	6471.32	0.742162	10363.45
0.922556	12203.42	1.055669	23799.64	0.514512	11348.91	0.675398	6264.648	0.689615	10105.92
0.870355	11805.19	1.107682	24659.35	0.566479	11954.31	0.623094	6047.588	0.637174	9797.855
0.818048	11371.58	1.159907	25500.58	0.618628	12591.68	0.570846	5770.733	0.585207	9442.135
0.765725	10945.19	1.211887	26341.19	0.670694	13190.86	0.518594	5559.997	0.53277	9101.491
0.7135	10565.69	1.264124	27170.44	0.722949	13809.89	0.466129	5356.165	0.480483	8727.424
0.661054	10138.85	1.31623	28007.58	0.77512	14450.73	0.414093	5166.951	0.4283	8363.435
0.609087	9793.269	1.368165	28826.32	0.827277	15034.11	0.361854	4937.192	0.375801	7941.184
0.556803	9410.849	1.377268	29042.52	0.879303	15646.48	0.30942	4678.13	0.323838	7530.963
0.504514	8995.94	1.325328	28377.21	0.931574	16235.97	0.257205	4447.405	0.271494	7123.627
0.452305	8555.431	1.272936	27709.85	0.983585	16891.93	0.205181	4256.884	0.219242	6728.501
0.400095	8080.829	1.220859	27017.99	1.035691	17566.01	0.15277	4003.548	0.166989	6304.415
0.347582	7633.926	1.168338	26281.61	1.087832	18154.19	0.10049	3764.502	0.114993	5869.033
0.295448	7201.738	1.116027	25552.42	1.139904	18768.4	0.048197	3497.989	0.062571	5450.317
0.191003	6348.046	1.011487	24022.74	1.244149	20008.05	-0.056193	2949.998	-0.041869	4595.428
0.138583	5900.176	0.959285	23261.08	1.296274	20625.47	-0.108179	2666.336	-0.093968	4157.296
0.086393	5467.267	0.907111	22445.36	1.348266	21196.67	-0.160524	2372.073	-0.146112	3711.108
0.03415	5028.891	0.854689	21689.76	1.38621	21690.17	-0.213039	2089.983	-0.198506	3257.952
-0.018192	4590.553	0.802308	20954.38	1.345729	21402.22	-0.264999	1808.909	-0.250793	2796.559
-0.070021	4168.347	0.750429	20161.11	1.293157	20938.57	-0.317104	1519.155	-0.303054	2342.005
-0.122194	3730.982	0.697933	19382.12	1.240829	20482.29	-0.369285	1216.469	-0.354892	1889.641

-0.174714	3311.783	0.645817	18626.74	1.188323	19935.79	-0.421546	930.9463	-0.407455	1457.396
-0.227113	2893.558	0.593387	17829.55	1.136311	19454.49	-0.473558	657.2019	-0.459381	1032.827
-0.279239	2470.811	0.54101	17047.86	1.083881	19027.82	-0.525904	380.463	-0.511612	603.3315
-0.331554	2065.105	0.489044	16259.23	1.031606	18491	-0.578457	165.1099	-0.563956	237.5533
-0.383711	1659.869	0.436494	15441.32	0.979507	17940.76	-0.630408	57.3046	-0.616302	34.46842
-0.43584	1257.08	0.384396	14621.85	0.92716	17400.69	-0.682673	27.32648	-0.668442	-14.48189
-0.487931	878.8855	0.332012	13840.14	0.875182	16864.03	-0.735042	12.50164	-0.720753	-52.15579
-0.540262	531.6544	0.279836	13072.6	0.822613	16287.47	-0.78719	-17.72764	-0.773206	-84.98682
-0.592649	268.0659	0.227619	12283.31	0.770282	15679.53	-0.839265	-51.29283	-0.825258	-125.6489
-0.644639	145.0429	0.175432	11475.76	0.718102	15092.85	-0.891432	-101.1576	-0.877407	-168.713
-0.69679	81.33218	0.123043	10692.75	0.665821	14531.3	-0.944103	-166.3818	-0.929397	-235.8048
-0.749031	3.794783	0.070924	9913.929	0.613569	13943.48	-0.996214	-231.1809	-0.981825	-326.4024
-0.80127	-97.17771	0.01866	9114.635	0.561407	13305.27	-1.048419	-298.2984	-1.034127	-411.2428
-0.853629	-220.117	-0.033526	8313.043	0.509025	12693.83	-1.100676	-355.3051	-1.086163	-463.6449
-0.905968	-370.3038	-0.085945	7523.364	0.456609	12139.22	-1.152663	-389.9908	-1.13866	-506.1359
-0.958263	-542.9211	-0.137642	6755.349	0.404344	11577.12	-1.205421	-414.437	-1.190692	-521.7142
-1.009857	-741.279	-0.190263	5975.531	0.352453	11002.5	-1.257241	-404.5452	-1.242912	-507.3981
-1.062591	-932.8813	-0.242476	5199.055	0.300113	10408.28	-1.309408	-403.8368	-1.295279	-477.7291
-1.114571	-1113.922	-0.294824	4428.742	0.247651	9771.303	-1.361595	-377.6132	-1.347364	-457.675
-1.167126	-1271.077	-0.346828	3666.723	0.195467	9187.143	-1.371581	-315.6992	-1.379352	-397.8025
-1.219056	-1405.132	-0.398976	2926.17	0.143107	8556.191	-1.319891	-212.5822	-1.334303	-243.7324
-1.271478	-1496.727	-0.451342	2195.276	0.090921	7934.757	-1.267446	-145.8382	-1.282363	-155.1182
-1.323454	-1544.725	-0.503647	1503.332	0.038673	7341.305	-1.215256	-97.08111	-1.229919	-92.80496
-1.374371	-1554.359	-0.555723	912.5215	-0.013331	6736.229	-1.163258	-62.112	-1.177912	-48.49144
-1.358528	-1270.053	-0.607922	531.706	-0.065634	6124.088	-1.110872	-32.07592	-1.125489	-29.19725
-1.306271	-939.6561			-0.117999	5513.738	-1.058967	-14.62357	-1.073492	-11.33274
-1.253823	-678.5922			-0.170085	4907.155	-1.006718	-1.176883	-1.021098	6.454496
-1.201397	-478.7531					-0.954317	1.663149	-0.968889	11.41328
-1.149284	-321.7785					-0.902356	14.556	-0.916846	18.73554
-1.097378	-200.314					-0.849978	13.17784	-0.864857	24.94369
-1.04503	-109.6777					-0.798015	15.41251	-0.812589	30.23091
-0.992938	-43.24285					-0.745673	16.34631	-0.760391	28.55008
-0.888702	40.62505					-0.641292	21.47898	-0.655842	32.10495
-0.83643	59.96431					-0.58901	29.60624	-0.603792	38.96353
						-0.537073	30.01195	-0.551609	42.63432
						-0.484939	31.61551	-0.499758	47.29687

B.1.3.2-Pac 2 Anodize Type II

Pac 2 Anodize Type II 1		Pac 2 Anodize Type II 2		Pac 2 Anodize Type II 3		Pac 2 Anodize Type II 4		Pac 2 Anodize Type II 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
1.101154	243.169	-0.499027	0.961191	1.229732	188.7833	-0.108408	7.497774	0.066336	326.6762
1.048858	247.0587	-0.447072	5.19226	1.282036	188.4484	-0.0564	8.95321	0.11828	372.1489
0.996517	245.6999	-0.394754	4.91534	1.334061	188.0749	-0.004635	11.00756	0.170441	412.7015
0.944007	236.8449	-0.342452	18.9867	1.382741	186.1622	0.047876	15.29015	0.222676	457.7299
0.891833	227.816	-0.290516	30.49495	1.360399	180.012	0.099895	34.65518	0.274944	494.5601
0.839831	220.3457	-0.238221	47.41923	1.307862	163.8928	0.151982	115.8505	0.326936	535.8533
0.787306	209.4428	-0.186101	65.32238	1.255702	172.2197	0.204125	195.7578	0.379077	581.062
0.735124	195.5646	-0.133821	81.28066	1.203205	178.2024	0.256339	264.2341	0.431062	636.6777
0.682805	206.6156	-0.081698	106.3515	1.150828	185.3765	0.30867	306.7702	0.483109	687.077
0.630793	195.6161	-0.029928	137.4759	1.098642	182.0406	0.360616	320.262	0.535396	746.5374
0.578424	195.4422	0.022359	163.7189	1.04622	170.2748	0.412626	270.8158	0.587412	795.7775
0.526218	184.1401	0.074142	188.3067	0.994425	166.4237	0.464573	198.2436	0.639552	842.6155
0.473967	173.2179	0.126507	218.1303	0.941842	160.1833	0.516847	156.7637	0.691779	889.0929
0.421589	175.6715	0.178806	244.6695	0.889492	153.2732	0.569417	124.8793	0.743833	925.1117
0.369339	170.1073	0.23084	265.052	0.837355	147.4644	0.621087	106.7637	0.79589	991.3083
0.317069	161.0463	0.282745	293.1497	0.784704	147.3549	0.673253	89.56892	0.84804	1024.564
0.264718	146.3889	0.335289	309.8357	0.732718	142.8405	0.725511	75.98055	0.900087	1077.784
0.212518	152.3974	0.387158	333.2901	0.680444	140.2129	0.77762	69.06401	0.952255	1129.568
0.160247	138.7511	0.439369	351.7664	0.628197	130.8041	0.829369	56.02304	1.004458	1160.719
0.108174	131.9633	0.491268	373.7203	0.575911	128.1509	0.881859	57.24664	1.056542	1221.39
0.055831	118.4651	0.543493	394.3154	0.523536	113.8412	0.934028	43.40712	1.108674	1276.98
0.003458	115.6766	0.595651	410.7438	0.471131	115.7346	0.986099	43.73556	1.160639	1322.716
-0.048718	100.8711	0.647722	429.6902	0.418924	105.4692	1.038032	39.56889	1.213019	1412.123
-0.10092	93.85794	0.700011	450.047	0.366906	107.5429	1.090374	39.97461	1.265011	1437.271
-0.15309	83.15469	0.751917	476.0838	0.314749	101.1029	1.142397	42.00964	1.317116	1511.009
-0.205425	75.83243	0.804056	491.2951	0.262295	93.7549	1.194525	38.39681	1.369134	1564.911
-0.257511	61.42619	0.85628	510.454	0.210221	92.39607	1.24669	39.61397	1.377098	1572.407
-0.309778	56.2742	0.90838	519.9981	0.157672	79.94114	1.298576	30.18583	1.325169	1539.512
-0.362245	48.88754	0.960438	535.2093	0.105513	78.65314	1.350999	33.34787	1.272818	1508.658
-0.414344	28.75616	1.012712	545.011	0.053132	74.45428	1.38601	29.98619	1.220632	1456.037
-0.466356	17.28011	1.064827	549.3386	0.000849	63.4419	1.343369	30.81051	1.168301	1461.292
-0.518797	-4.222995	1.116673	562.9334	-0.051139	59.64876	1.291239	25.69073	1.115834	1390.31
-0.570918	-11.1975	1.169027	581.9378	-0.103202	56.2098	1.238714	22.30973	1.063681	1367.725
-0.623296	-23.67818	1.221123	611.7614	-0.155316	28.4084	1.186611	24.32545	1.011283	1321.312

-0.675747	-22.82167	1.27307	624.0103	-0.207858	-51.11251	1.13422	20.02354	0.959058	1294.477
-0.727741	-28.48885	1.325104	642.8021	-0.260179	-213.8444	1.081956	17.01607	0.906722	1258.098
-0.832143	-31.39328	1.368981	664.5564	-0.364504	-559.24	0.977255	14.59464	0.80209	1159.237
-0.8844	-22.69931	1.316548	646.4343	-0.417099	-714.8364	0.924736	12.59824	0.749922	1136.575
-0.936541	-16.79384	1.264239	627.9193	-0.468823	-796.3666	0.87261	10.90453	0.697785	1103.796
-0.98908	-27.62589	1.211966	622.0783	-0.521305	-857.3918	0.820372	10.44085	0.645349	1035.912
-1.041103	-29.75109	1.159667	611.0337	-0.57328	-891.9101	0.768415	9.481288	0.59291	974.5386
-1.092982	-29.99581	1.107303	601.7665	-0.625664	-747.7254	0.715985	12.19896	0.541109	930.7209
-1.145511	-37.31163	1.05515	576.5862	-0.677989	-246.1216	0.663744	7.645893	0.48844	883.8958
-1.198012	-34.92239	1.002811	545.6099	-0.730022	-40.9309	0.611444	6.080977	0.436212	837.309
-1.250064	-33.13208	0.950652	546.6467	-0.782537	-31.0906	0.559165	5.752538	0.384159	791.5464
-1.302249	-37.85259	0.898248	529.6323	-0.834512	-24.23846	0.5069	1.141511	0.331851	750.6719
-1.354403	-31.27092	0.845815	517.8342	-0.886607	-27.47133	0.454772	5.301739	0.279486	707.1698
-1.376212	-29.04913	0.79361	495.3265	-0.93921	-28.76577	0.402228	8.373611	0.227195	663.2684
-1.326937	-16.47828	0.741453	466.8489	-0.991331	-32.41724	0.350126	6.113177	0.174949	628.5054
-1.27492	-10.88838	0.689214	459.2368	-1.043517	-30.47237	0.297755	-1.370083	0.122969	598.3662
-1.222763	-8.466944	0.636898	445.7	-1.09577	-37.38891	0.245485	-0.462045	0.070545	549.8216
-1.170255	-5.453032	0.584468	435.0225	-1.14804	-36.90591	0.193197	1.714669	0.018178	511.0787
-1.118112	-0.732524	0.53228	409.855	-1.200238	-39.3531	0.141191	-0.436285	-0.033494	466.1791
-1.066152	-4.628714	0.480078	399.5575	-1.252817	-46.392	0.08876	4.226262	-0.086062	422.1039
-1.013987	-2.3876	0.427808	386.6067	-1.304879	-45.99916	0.036397	-4.538554	-0.138305	375.3174
-0.961752	3.079945	0.375458	377.668	-1.357098	-53.59834	-0.015372	-4.409755	-0.19057	330.186
-0.909415	-0.049886	0.323375	343.2785	-1.375108	-39.3853	-0.067849	-0.249526	-0.242777	291.6491
-0.857301	2.146148	0.271095	336.4392	-1.324843	-21.96515	-0.120397	0.272113	-0.295341	245.6934
-0.805057	-1.711402	0.218839	320.9897	-1.27258	-12.69157	-0.172271	-2.992958	-0.347058	203.9237
-0.753008	-0.223766	0.166675	306.474	-1.220454	-4.538554	-0.224309	-33.38324	-0.399554	157.3369
-0.700947	1.48283	0.114159	285.2349	-1.168246	3.472784	-0.276629	-141.1757	-0.45167	119.5792
-0.648676	2.745066	0.061921	261.3812	-1.115907	9.365369	-0.328732	-252.4135	-0.503938	76.98519
-0.59646	2.635587	0.009798	247.4387	-1.063895	10.20257	-0.381087	-354.1588	-0.55601	41.01144
-0.54435	0.297873	-0.042217	228.2346	-1.011602	10.07377	-0.433447	-447.1521	-0.608203	13.96996
-0.492356	3.543624	-0.09472	210.3444	-0.959427	7.504214	-0.485774	-535.4829	-0.660687	3.859183
-0.440245	-1.756482	-0.146901	191.2498	-0.907162	11.5614	-0.537979	-584.2786	-0.712993	-3.553237
-0.387976	5.900658	-0.199029	171.8912	-0.855027	16.66831	-0.59006	-527.5939	-0.765233	-15.64109
-0.335911	14.97459	-0.2514	159.3011	-0.80287	12.34064	-0.642476	-176.8145	-0.817491	-31.58648
-0.283773	26.94652	-0.303602	139.0409	-0.75082	17.54415	-0.694529	-38.9345	-0.86974	-41.81962
-0.231316	29.78011	-0.355968	110.0996	-0.698469	16.19819	-0.746882	-21.48215	-0.922023	-58.07413
-0.17962	32.74251	-0.408104	87.23764	-0.646352	17.79531	-0.799125	-12.77529	-0.974196	-81.74751
-0.127216	38.65441	-0.46019	66.23042	-0.594128	15.54131	-0.851217	-14.38529	-1.02665	-107.8681
-0.075186	51.92722	-0.512631	43.6132	-0.54217	16.16599	-0.903528	-17.9466	-1.078381	-129.0427
-0.022835	58.21908	-0.564813	20.47434	-0.489793	20.02354	-0.956107	-12.60141	-1.130629	-144.5051
0.081079	85.59545	-0.669153	1.643829	-0.385922	28.38264	-1.060286	-11.08802	-1.235297	-161.423

0.133407	96.73018	-0.721447	-1.402283	-0.333542	28.64024	-1.112409	-13.04577	-1.287634	-162.0348
0.185556	110.75	-0.773468	-8.125625	-0.281225	29.88315	-1.164939	-14.75881	-1.339733	-142.7406
0.237517	119.3796	-0.825779	-9.278382	-0.229208	36.49702	-1.217093	-14.57205	-1.379882	-119.7627
0.289863	117.5957	-0.878152	-13.88941	-0.177172	40.14205	-1.269164	-17.85644	-1.342052	-81.48347
0.341723	135.1576	-0.930434	-26.6277	-0.124794	49.77626	-1.321561	-23.19518	-1.289628	-54.0749
0.393962	143.0787	-0.982639	-34.58751	-0.072515	56.55112	-1.372642	-25.04346	-1.237458	-31.03264
0.446017	149.7506	-1.03504	-42.89509	-0.020681	62.75927	-1.360208	-9.458701	-1.185373	-20.07179
0.498208	156.7573	-1.087224	-54.24878	0.03143	79.76082	-1.308017	-3.804396	-1.133204	-10.17998
0.550342	162.2699	-1.139253	-62.9492	0.083419	105.7397	-1.255813	-0.249526	-1.080938	-3.160398
0.60275	172.0007	-1.191532	-67.32839	0.135787	228.5888	-1.203513	3.485664	-1.028514	3.105705
0.654401	182.0793	-1.243748	-74.86961	0.187834	357.7878	-1.15134	6.422297	-0.976622	0.433112
0.706843	187.9912	-1.296129	-73.44637	0.239832	475.0599	-1.099102	2.017348	-0.924537	1.28319
0.758709	191.3979	-1.348194	-66.48475	0.292107	559.5653	-1.046902	4.792981	-0.872329	3.247385
0.811081	194.6244	-1.379099	-49.93399	0.344019	619.1738	-0.994694	4.432342	-0.819824	6.377216
0.86313	201.5795	-1.333903	-30.8008	0.396203	616.0891	-0.942475	3.215185	-0.767908	9.687368
0.915377	212.315	-1.281368	-22.31291	0.448419	509.9259	-0.890665	6.325697	-0.715747	10.29273
0.967267	216.4173	-1.229025	-11.24258	0.500326	408.0068	-0.838441	5.675259	-0.663631	9.487728
1.019337	219.2187	-1.17703	-8.177145	0.552531	372.0781	-0.786365	8.71493	-0.611452	7.298134
1.071587	230.1151	-1.124661	-5.678431	0.60454	348.6044	-0.734037	10.47949	-0.559245	9.313849
1.123363	236.9415	-1.07279	-4.377555	0.657013	335.0096	-0.681817	7.819773	-0.507126	8.57969
1.17601	253.7241	-1.020335	-2.902799	0.708983	320.1396	-0.62961	9.693808	-0.45504	11.5614
1.228103	256.9248	-0.968187	-0.346126	0.761232	308.8632	-0.577457	6.937495	-0.402857	26.4442
1.280131	258.8439	-0.916353	3.015545	0.813129	293.2849	-0.52535	10.25409	-0.350945	40.9406
1.332156	257.2983	-0.86403	1.38623	0.865395	280.6303	-0.473163	11.74816	-0.298739	63.12635
1.38217	287.3601	-0.811823	-1.144684	0.917555	273.2308	-0.421079	8.019412	-0.246525	85.18973
1.362199	281.0747	-0.759597	-1.305683	0.969557	259.8871	-0.369019	5.559339	-0.194327	111.774
1.309823	271.389	-0.707353	-1.563282	1.021625	249.2354	-0.316986	6.621936	-0.14199	149.3191
1.257617	272.3228	-0.655163	1.991588	1.073697	244.9077	-0.264583	7.723173	-0.089967	192.9564
1.205289	269.9013	-0.60315	-0.255966	1.125756	245.0752	-0.212548	10.35713	-0.03791	235.6857
1.153123	262.3472	-0.551176	3.350424	1.178112	242.0613	-0.160634	5.958618	0.014032	276.966
1.100442	257.9745	-0.49893	1.08999	1.230295	239.466	-0.108478	13.39036	0.066181	320.6419
1.048248	247.5159	-0.446762	2.551867	1.282215	240.6767	-0.056269	11.09128	0.118392	357.7942
0.996265	237.959	-0.394489	11.03976	1.334663	233.0324	-0.003797	13.67372	0.170516	408.7216
0.943921	230.1022	-0.342559	18.49726	1.383341	225.9613	0.048004	23.19201	0.222538	460.6021
0.891419	219.0963	-0.290421	34.37826	1.360045	215.696	0.100244	40.63793		
				1.307522	207.9744	0.152189	125.7359		
				1.255611	190.9858	0.204604	204.4196		
				1.150795	183.2191				
				1.098527	174.1581				
				1.046096	171.8397				
				0.993987	165.2387				

				0.94162	159.2238				
				0.889108	153.46				
				0.836926	145.629				

B.1.3.3-Pac 2 Anodize Type III

Pac 2 Anodize Type III 1		Pac 2 Anodize Type III 2		Pac 2 Anodize Type III 3		Pac 2 Anodize Type III 4		Pac 2 Anodize Type III 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
1.074631	1907.428	-1.100015	-20.85103	0.793618	1788.05	0.518818	741.5335	-1.020353	-2.992958
1.022557	1840.993	-1.152133	-18.9126	0.741564	1734.251	0.571053	780.2893	-0.968115	-2.883479
0.970183	1819.477	-1.204401	-21.69467	0.68927	1671.48	0.623374	818.6008	-0.916101	-2.072041
0.917957	1764.248	-1.256606	-16.48472	0.637127	1618.395	0.675697	866.9329	-0.863707	-1.479562
0.865785	1687.844	-1.308818	-15.67329	0.584929	1570.508	0.727877	929.6648	-0.811544	-1.865961
0.813448	1621.538	-1.360932	-17.18024	0.532208	1498.663	0.779598	1010.841	-0.759466	-3.173278
0.761158	1586.034	-1.372073	-14.49477	0.480243	1448.264	0.83189	1063.352	-0.707241	0.864591
0.708809	1510.481	-1.320336	-10.47622	0.42794	1408.001	0.883936	1118.672	-0.655309	0.066033
0.656341	1450.299	-1.268406	-5.317792	0.375687	1300.698	0.93576	1150.994	-0.60305	4.116783
0.604262	1394.484	-1.215834	-8.505584	0.323485	1218.852	0.988092	1195.842	-0.550772	0.349393
0.55194	1367.816	-1.16382	-8.151385	0.271275	1145.024	1.040306	1226.922	-0.498763	0.652072
0.499752	1297.053	-1.111709	-5.794351	0.219014	1086.221	1.091988	1259.811	-0.446265	3.028426
0.447502	1208.452	-1.059512	-5.195433	0.166583	1031.172	1.144475	1288.7	-0.39443	9.603648
0.395465	1140.568	-1.007385	-2.194401	0.114307	955.6694	1.196544	1296.86	-0.342173	8.495971
0.343056	1080.702	-0.955436	-0.301046	0.062139	890.9733	1.24865	1328.332	-0.290043	18.90298
0.290852	1026.033	-0.903188	-2.4198	0.010069	825.1309	1.300724	1410.377	-0.237929	26.72112
0.238535	965.6385	-0.850663	-2.980079	-0.042107	744.9338	1.352821	1479.543	-0.185954	47.03927
0.186395	904.4265	-0.798645	1.508589	-0.09452	686.3107	1.38592	1547.04	-0.133569	57.21444
0.134099	851.5928	-0.746579	1.759749	-0.146526	616.1792	1.341887	1538.327	-0.081363	73.95196
0.08187	808.1938	-0.694451	-3.630517	-0.198812	565.9796	1.289409	1498.592	-0.029435	92.03543
0.029672	737.6631	-0.642127	1.450629	-0.251215	494.1802	1.237264	1483.523	0.022558	106.519
-0.022615	683.2967	-0.590234	0.710031	-0.303407	425.3561	1.184774	1445.134	0.074818	132.1758
-0.074721	606.5321	-0.537929	-1.692082	-0.355776	352.5005	1.132221	1393.84	0.126931	165.7153
-0.127078	542.5316	-0.485746	1.965828	-0.407979	278.1252	1.080028	1363.9	0.179079	193.7163
-0.179242	487.7788	-0.433554	1.920748	-0.45996	204.9605	1.027865	1312.238	0.231043	218.0981
-0.231648	430.5403	-0.381507	16.75203	-0.512424	123.5656	0.975614	1271.634	0.283393	242.4219
-0.283814	372.0652	-0.329394	25.58769	-0.564578	57.90996	0.923042	1229.762	0.335342	275.1563
-0.33598	304.9541	-0.277041	42.06116	-0.616701	16.51375	0.871175	1182.756	0.387664	301.5088

-0.388381	246.8591	-0.225091	57.7554	-0.669132	-0.481365	0.818736	1136.234	0.439573	312.7787
-0.440389	183.6699	-0.172961	75.87107	-0.721191	-10.5857	0.766355	1092.944	0.491728	327.2172
-0.492705	117.0354	-0.120818	114.5238	-0.773403	-10.8755	0.714209	1060.145	0.544097	347.2198
-0.545028	55.43057	-0.068749	149.1259	-0.825933	-21.53367	0.661826	1016.592	0.596052	360.9047
-0.597273	-35.36675	-0.016573	186.1622	-0.877891	-37.45975	0.609477	972.7869	0.648076	371.5178
-0.649445	-82.88738	0.035378	223.3274	-0.930228	-51.69211	0.557533	956.5903	0.700186	397.2584
-0.70165	-107.1404	0.087548	256.9054	-0.9827	-76.95616	0.504963	912.8113	0.752535	404.5485
-0.754011	-129.9443	0.139792	291.5268	-1.034648	-99.2707	0.452736	862.1222	0.80457	415.6639
-0.858391	-114.4819	0.244077	354.4647	-1.139294	-131.7604	0.348556	784.9454	0.908541	438.2103
-0.910625	-77.6388	0.296199	378.7886	-1.191473	-135.8305	0.296206	744.0258	0.960801	452.6294
-0.962889	-97.7895	0.348172	404.1879	-1.243725	-130.305	0.243785	694.7792	1.013079	473.0957
-1.015089	-123.9165	0.400285	436.8514	-1.296095	-120.6836	0.191542	649.6543	1.065161	474.3966
-1.067247	-152.1365	0.452542	466.4818	-1.348085	-107.0695	0.139459	613.629	1.117382	498.4177
-1.119547	-175.0757	0.504573	494.9401	-1.379089	-87.25369	0.087098	559.8487	1.169246	525.0728
-1.171678	-195.9348	0.556646	527.4169	-1.333889	-50.05635	0.035082	525.5815	1.221435	538.5903
-1.223912	-206.7991	0.60881	569.6954	-1.281658	-33.71812	-0.017273	481.8798	1.273531	554.8062
-1.276329	-209.6391	0.661181	588.8479	-1.229485	-21.55299	-0.069281	431.912	1.32582	564.6594
-1.328404	-201.982	0.713117	600.0084	-1.17737	-10.16066	-0.121743	391.8553	1.377379	598.1022
-1.377228	-189.3532	0.76523	622.9219	-1.125208	-10.69518	-0.17414	352.5134	1.368334	603.3765
-1.353717	-137.6272	0.817316	651.5541	-1.07309	-2.728919	-0.226454	300.5041	1.316322	595.2557
-1.301366	-86.31346	0.869527	687.9529	-1.02085	-0.294606	-0.278665	264.4595	1.264002	577.4556
-1.249252	-58.50561	0.921606	711.9096	-0.968482	4.438782	-0.330605	220.0752	1.211566	565.3871
-1.197012	-35.41827	0.973733	747.0655	-0.91637	2.551867	-0.382831	172.1295	1.159412	554.7997
-1.144674	-19.50507	1.02574	788.3522	-0.864141	1.476389	-0.435103	126.4249	1.107045	539.1119
-1.092648	-12.71733	1.077898	826.2773	-0.811823	3.569384	-0.487828	78.18947	1.054796	525.6266
-1.0401	-5.472352	1.130051	828.5119	-0.759949	3.723943	-0.539849	46.62711	1.002448	511.7613
-0.988177	-3.907436	1.182067	860.8793	-0.707889	4.89602	-0.592208	11.63868	0.950043	491.8682
-0.936054	0.594112	1.234342	877.2626	-0.655557	6.010137	-0.643995	-1.325003	0.897965	477.3267
-0.883953	-0.874204	1.28628	883.181	-0.603232	4.88958	-0.696469	-1.325003	0.845745	466.8747
-0.831703	3.820543	1.338452	910.9759	-0.551387	7.368974	-0.748527	-7.037267	0.793406	449.9439
-0.779507	9.262329	1.384765	951.6444	-0.499216	3.189425	-0.801108	-13.58029	0.741009	430.2118
-0.727258	1.10287	1.355729	978.7053	-0.446955	9.758207	-0.85289	-23.44634	0.688945	413.1587
-0.675158	6.184017	1.303416	971.486	-0.394935	13.08124	-0.905329	-28.68849	0.636705	398.8555
-0.62317	4.432341	1.250988	950.4724	-0.342552	42.8404	-0.957694	-35.65655	0.584347	377.4877
-0.570806	6.061657	1.198715	956.3134	-0.290698	84.99009	-1.010085	-52.29103	0.532081	358.7216
-0.518837	8.56037	1.14629	934.3982	-0.238464	136.613	-1.062295	-62.80108	0.479648	349.229
-0.466587	18.29762	1.094233	907.5949	-0.186353	190.4641	-1.114445	-74.72149	0.427704	332.1438
-0.414513	44.48904	1.041853	889.0607	-0.134035	276.7277	-1.166352	-71.28254	0.374951	318.2076
-0.362211	79.1941	0.989528	863.3845	-0.082178	382.3563	-1.218752	-70.5677	0.323021	299.1646
-0.3103	130.2567	0.937214	851.0776	-0.029901	449.7636	-1.271028	-65.26115	0.270736	285.1834
-0.258017	167.4476	0.885021	852.5009	0.022179	532.4981	-1.323383	-54.74466	0.218305	263.5322

-0.205827	192.6086	0.832707	820.7324	0.074477	613.79	-1.373824	-51.93683	0.166539	245.5195
-0.153654	196.8977	0.780381	788.5905	0.12631	689.6659	-1.358162	-35.38607	0.114173	227.7774
-0.10167	228.3055	0.728172	777.1144	0.178435	777.0049	-1.306314	-20.96051	0.061708	208.5798
-0.049508	278.7563	0.676015	764.7561	0.230658	896.2799	-1.254089	-12.16993	0.009529	191.4881
0.002594	344.4506	0.62355	735.525	0.282619	987.3863	-1.201754	-5.498112	-0.0426	173.5141
0.106798	477.4105	0.51911	646.3248	0.386801	1098.933	-1.097412	-4.068435	-0.147256	141.121
0.158891	553.6856	0.466556	622.7802	0.438982	1187.67	-1.045322	2.848106	-0.199692	129.7995
0.210925	666.0698	0.414737	602.9	0.491276	1249.004	-0.993272	-2.291	-0.251593	112.0895
0.263303	720.0948	0.362323	570.6292	0.543265	1291.933	-0.940721	2.545427	-0.303944	92.43471
0.315222	797.5807	0.31006	537.1156	0.595542	1301.986	-0.888559	-0.842004	-0.355956	76.49575
0.367377	855.5792	0.257808	506.1457	0.647482	1352.302	-0.83644	1.894989	-0.408497	53.29249
0.41958	962.7856	0.205699	477.8677	0.699715	1441.914	-0.784554	1.882109	-0.460477	30.68171
0.47176	1041.218	0.153247	448.4305	0.751931	1534.424	-0.73206	4.387262	-0.512814	5.275979
0.523849	1107.576	0.100918	416.3852	0.804117	1594.278	-0.679912	1.186591	-0.56517	-14.58493
0.575845	1170.514	0.048893	389.2922	0.855906	1738.076	-0.628265	-1.473122	-0.617427	-22.70575
0.628008	1238.25	-0.003331	362.7079	0.907955	1815.388	-0.57585	4.670621	-0.669583	-22.18411
0.67992	1321.177	-0.055677	332.0858	0.960103	1859.193	-0.523701	3.859183	-0.722199	-15.94376
0.732165	1369.896	-0.10773	300.781	1.012441	1923.2	-0.471597	4.863821	-0.774053	-14.32733
0.784293	1419.921	-0.160109	272.6383	1.064311	1997.009	-0.419341	1.611629	-0.826365	-18.21064
0.836502	1492.371	-0.212311	242.6924	1.116462	2036.466	-0.367143	12.50808	-0.878472	-21.26963
0.888608	1558.613	-0.264623	211.4327	1.1689	2083.292	-0.314907	33.77934	-0.930775	-29.43553
0.940802	1614.596	-0.316953	179.69	1.220985	2136.911	-0.262712	58.90816	-0.983027	-30.8652
0.992762	1661.659	-0.368947	141.2047	1.272963	2237.961	-0.210785	97.40637	-1.035456	-39.89406
1.044841	1737.632	-0.421407	102.9641	1.324944	2313.444	-0.15884	140.9085	-1.087326	-45.8768
1.097292	1772.234	-0.473522	64.45942	1.376794	2370.65	-0.106614	185.6277	-1.139573	-49.85027
1.149116	1834.682	-0.525621	30.17939	1.369482	2428.571	-0.054649	243.7743	-1.192106	-50.59087
1.201237	1842.919	-0.5779	7.349654	1.317164	2360.25	-0.002273	294.2251	-1.243793	-47.9698
1.253456	1889.107	-0.63012	-6.27735	1.264795	2284.96	0.049858	345.7386	-1.296573	-41.19494
1.305469	1927.27	-0.682242	-13.14881	1.212478	2214.687	0.101884	394.9851	-1.348751	-41.45898
1.357607	1991.058	-0.734464	-10.95922	1.160221	2128.384	0.154064	457.4079	-1.379079	-33.86624
1.384301	2028.281	-0.786973	-12.08621	1.107573	2087.568	0.206154	513.8415	-1.333436	-26.4989
1.336573	2058.079	-0.839147	-12.37601	1.055643	2020.308	0.258482	559.1854	-1.281277	-14.96489
1.284333	2023.754	-0.891585	-15.59601	1.003434	1980.503	0.310282	609.0566	-1.228905	-9.677661
1.232123	1977.618	-0.943766	-24.9211	0.950987	1915.601	0.362583	660.3253	-1.176707	-8.653703
1.179693	1930.574	-0.996094	-28.53393	0.898816	1870.785	0.414789	706.1909	-1.124682	-7.887345
1.127232	1884.09	-1.048069	-36.11379	0.84648	1794.291	0.466859	759.7909	-1.07234	-7.655506
1.074984	1806.952	-1.100186	-39.48834	0.794158	1722.981	0.518832	819.4251	-1.020381	-6.18719
1.022737	1759.843	-1.152684	-43.97701	0.741951	1670.798	0.570939	851.7603	-0.967836	-2.194401
0.970562	1696.396	-1.204737	-43.38453	0.689657	1597.401	0.623097	904.5488	-0.915981	-4.757514
0.918191	1651.381	-1.256964	-39.69442	0.637258	1562.297	0.675364	965.7094	-0.863588	-3.340718
0.866096	1584.946	-1.30932	-39.82322			0.727489	1003.254	-0.811478	-2.36828

0.813659	1497.768	-1.361399	-35.68231			0.77931	1041.199	-0.759268	-2.986519
0.761155	1457.318	-1.371942	-33.2802			0.831709	1070.939		
0.656933	1353.184	-1.26785	-11.21682			0.935756	1124.848		
0.604732	1298.953	-1.215823	-6.863388			0.988052	1168.363		
0.552382	1237.96	-1.16355	-5.330672			1.040043	1223.927		
0.500133	1154.935	-1.11139	-7.700586			1.092091	1242.455		
0.447914	1110.751	-1.05916	-3.256998						
0.395634	1060.796	-1.007234	-3.791516						
0.343473	1016.102	-0.954995	-1.936801						
0.29116	959.9391	-0.902594	-1.370083						
0.23893	911.3559								
0.186697	845.5328								
0.13442	792.2226								
0.082065	734.0116								
0.02979	681.6932								
-0.022441	617.6025								
-0.074598	548.8943								
-0.126564	500.3819								
-0.178927	443.2013								
-0.231063	392.6088								
-0.283671	332.6654								
-0.335569	289.3629								
-0.388028	236.9415								
-0.44009	177.2364								
-0.492479	118.1624								
-0.54459	34.71958								
-0.596936	-48.40128								
-0.649118	-84.5167								
-0.701295	-110.9657								
-0.753444	-131.7991								
-0.805955	-119.7112								

B.1.3.4-Pac 2 Natural Oxide

Pac 2 Natural Oxide 1		Pac 2 Natural Oxide 2		Pac 2 Natural Oxide 3		Pac 2 Natural Oxide 4		Pac 2 Natural Oxide 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps

-0.344532	5972.259	-1.067466	5.604419	-0.8862	32.20155	-0.802772	-186.5003	-0.428792	360.3573
-0.396621	4700.606	-1.015225	22.99881	-0.833678	40.70233	-0.855143	-400.2755	-0.376989	769.0451
-0.449123	3454.635	-0.962962	32.70387	-0.781418	45.02999	-0.907298	-686.6228	-0.324889	1494.29
-0.501269	2260.571	-0.91092	35.4151	-0.729826	45.02355	-0.958934	-1022.68	-0.272646	2352.348
-0.553328	1208.342	-0.858672	44.36024	-0.677764	48.93906	-1.012055	-1393.211	-0.220441	3303.289
-0.605793	515.2904	-0.806387	43.86436	-0.625327	50.85174	-1.063807	-1767.458	-0.16858	4391.969
-0.65782	262.0703	-0.75419	47.11655	-0.573347	60.29919	-1.116181	-2128.212	-0.116331	5616.405
-0.709918	143.0272	-0.702118	50.4267	-0.520771	54.94113	-1.168478	-2449.432	-0.064589	6911.339
-0.762007	-23.6331	-0.649783	54.29713	-0.468794	75.58127	-1.220449	-2726.332	-0.012119	8237.791
-0.814545	-243.9385	-0.598039	59.86771	-0.41674	141.2627	-1.272892	-2938.71	0.039889	9521.798
-0.866985	-523.3951	-0.545607	60.67271	-0.364521	354.1299	-1.325072	-3089.65	0.09214	10754.66
-0.918958	-917.7151	-0.493603	67.54417	-0.312422	680.798	-1.37567	-3160.258	0.143942	11940.06
-0.971265	-1416.672	-0.441343	96.60138	-0.260456	1069.213	-1.356587	-2581.02	0.196152	13105.73
-1.023616	-1979.41	-0.389272	260.4667	-0.208357	1532.087	-1.304147	-1904.14	0.248379	14230.87
-1.075682	-2548.911	-0.337068	615.664	-0.156157	2085.552	-1.252093	-1384.472	0.300376	15355.91
-1.127707	-3092.586	-0.284963	1093.846	-0.104035	2742.933	-1.199945	-997.2747	0.352689	16471.03
-1.180017	-3592	-0.232968	1679.176	-0.051944	3433.821	-1.147549	-674.2452	0.404832	17588.01
-1.232093	-4016.749	-0.180986	2369.452	0.00006	4135.922	-1.095477	-430.5241	0.456714	18695.88
-1.284442	-4394.235	-0.1286	3134.825	0.05211	4797.895	-1.043354	-244.9817	0.508815	19813.82
-1.336606	-4709.368	-0.076692	3942.233	0.104403	5465.226	-0.991278	-115.7893	0.56111	20928.63
-1.379738	-4782.205	-0.024497	4759.892	0.156552	6115.027	-0.938966	-21.11507	0.613178	22021.79
-1.345105	-3836.442	0.027784	5563.352	0.208558	6764.082	-0.886779	45.52587	0.665146	23120.83
-1.292784	-2908.841	0.079378	6380.761	0.260738	7393.965	-0.834576	85.28633	0.717463	24208.24
-1.240814	-2178.638	0.131942	7199.715	0.312965	8028.556	-0.782549	113.9121	0.769461	25316.67
-1.188457	-1581.458	0.183961	7998.333	0.3649	8642.481	-0.730222	139.0151	0.82144	26413.96
-1.136253	-1100.224	0.236008	8806.971	0.417127	9236.152	-0.678083	156.2292	0.87373	27537.88
-1.084539	-721.1798	0.288103	9567.374	0.469212	9890.726	-0.625899	172.4257	0.925909	28618.44
-1.031891	-426.0998	0.340248	10325.97	0.521171	10509.02	-0.573663	192.409	0.978153	29706.95
-0.980062	-201.1319	0.392287	11080.75	0.573558	11155.6	-0.521649	200.9484	1.030178	30827.39
-0.927886	-58.08701	0.444513	11879.89	0.625577	11810.75	-0.469481	233.7344	1.082141	31924.15
-0.876007	31.73143	0.496484	12639.64	0.677818	12441.8	-0.417271	386.7741	1.134298	33055.52
-0.823276	90.96639	0.548659	13404.62	0.729627	13074.84	-0.365499	863.9319	1.18651	34181.96
-0.770932	137.1604	0.600851	14151.55	0.78161	13707.7	-0.31336	1543.247	1.238647	35296.34
-0.718981	166.5332	0.652983	14930.79	0.834195	14325.59	-0.261113	2345.032	1.290977	36439.73
-0.666859	186.349	0.705021	15723.55	0.886256	15008.45	-0.209026	3263.973	1.342714	37540.21
-0.61511	207.1888	0.757368	16517.13	0.93843	15657.06	-0.156939	4276.648	1.385876	38503.58
-0.510293	271.0476	0.861623	18085.13	1.042564	16927.22	-0.052817	6478.224	1.298791	37047.84
-0.458222	369.5665	0.913611	18846.37	1.094597	17589.57	-0.000311	7594.281	1.246517	36125.1
-0.406063	736.2399	0.965746	19541.2	1.146731	18212.64	0.05152	8663.745	1.193968	35152.23
-0.354002	1519.426	1.018046	20330.55	1.198947	18969.85	0.10348	9708.062	1.141629	34193.14
-0.30185	2598.362	1.070002	21123.4	1.251007	19582.78	0.155898	10718.16	1.089364	33213.42

-0.250016	3818.604	1.121941	21914.01	1.302989	20242.28	0.207771	11706.62	1.036919	32231.4
-0.197663	5177.893	1.174325	22728.97	1.355083	20950.47	0.260224	12677.72	0.984716	31228.36
-0.14562	6660.624	1.226313	23573.44	1.385196	21364.74	0.311996	13659.02	0.932742	30185.73
-0.093282	8224.724	1.27829	24392.95	1.338707	20946.89	0.364156	14628.35	0.880387	29141.1
-0.041476	9842.213	1.330641	25150.01	1.286537	20430.82	0.416373	15599.96	0.827908	28108.64
0.010553	11452.93	1.381177	25923.11	1.234084	19917.6	0.468432	16573.66	0.77602	27086.07
0.062852	13036.66	1.36347	25899.25	1.181959	19356.2	0.520387	17539.95	0.723538	26051.66
0.114802	14562.12	1.311051	25393.24	1.129666	18850.31	0.572738	18516.29	0.671193	25027.09
0.167135	16068.11	1.258739	24794.41	1.077196	18340.93	0.625016	19500.72	0.61905	23999.7
0.219218	17567.17	1.206535	24198.56	1.024759	17836.68	0.677001	20446.67	0.566506	22962.95
0.271172	19035.61	1.154229	23560.29	0.972564	17304.87	0.729053	21408.11	0.514516	21899.76
0.323518	20490.41	1.102082	22875.74	0.920239	16766.18	0.7809	22353.52	0.462274	20862.66
0.375368	21935.71	1.049955	22228.32	0.868148	16187.74	0.833286	23325.62	0.409739	19812.21
0.427509	23391.22	0.997137	21657.81	0.815736	15657.98	0.885531	24304.46	0.357647	18746.87
0.479682	24834.32	0.945378	21045.62	0.76337	15103.08	0.937553	25317.4	0.305472	17693.94
0.531878	26232.87	0.893023	20408.37	0.711295	14527.83	0.989432	26305.88	0.253019	16641.42
0.583999	27635.7	0.840767	19748.17	0.659002	13934.61	1.04178	27273.15	0.200597	15587.89
0.635909	29036.62	0.788118	19061.64	0.606757	13371.5	1.093876	28248.85	0.148557	14529.9
0.688427	30470.76	0.735789	18413.83	0.554558	12833.23	1.146018	29222.46	0.096444	13469.45
0.740508	31912.92	0.683666	17736.78	0.502107	12238.97	1.198284	30195.55	0.044194	12420
0.792415	33331.93	0.631355	17013.78	0.450255	11671.89	1.250135	31164.42	-0.007962	11367.22
0.844959	34765.8	0.578968	16329.68	0.397812	11084.81	1.302202	32149.84	-0.059907	10311.73
0.896777	36171.09	0.527133	15610.27	0.345491	10506.65	1.354533	33113.98	-0.11237	9251.009
0.948914	37585.15	0.474769	14879.42	0.293141	9919.828	1.384885	33730.97	-0.164634	8199.261
1.000826	39007.85	0.422418	14152.42	0.240868	9340.447	1.339148	33097.26	-0.216985	7146.689
1.053152	40457.3	0.370136	13418.04	0.188973	8757.428	1.286669	32309.02	-0.269436	6102.952
1.105111	42014.27	0.317829	12687.68	0.136458	8165.728	1.234235	31495.98	-0.321437	5064.375
1.157379	43484.76	0.265699	11957.99	0.084062	7553.928	1.182151	30637.55	-0.373591	4044.944
1.209426	44907.27	0.21367	11234.39	0.031949	6954.377	1.129895	29772.34	-0.425924	3041.581
1.261588	46349.58	0.161334	10525.75	-0.020432	6374.598	1.077487	28915.31	-0.478027	2083.227
1.313519	47757.31	0.108715	9791.653	-0.072515	5766.411	1.025106	28039.14	-0.530343	1213.179
1.36564	49144.19	0.056817	9040.891	-0.124354	5155.617	0.973113	27130.93	-0.582365	592.5381
1.379498	49683.09	0.004529	8304.361	-0.176968	4557.148	0.920764	26253.78	-0.634346	317.5057
1.275955	47437.9	-0.099885	6823.781	-0.281328	3348.891	0.816105	24541.04	-0.739066	62.90095
1.223522	46294.11	-0.152204	6071.429	-0.333446	2757.964	0.76391	23632.32	-0.79139	-134.9096
1.17114	45008.03	-0.204627	5321.389	-0.385623	2167.25	0.711581	22730.7	-0.843526	-399.1034
1.118911	43803.53	-0.256711	4578.381	-0.438001	1579.833	0.659277	21817.05	-0.895732	-712.9237
1.066304	42542.99	-0.308648	3828.013	-0.490389	1027.449	0.60707	20899.24	-0.948214	-1108.641
1.014155	41232.58	-0.361148	3083.698	-0.542662	522.5419	0.554642	19996.6	-1.000353	-1537.441
0.962086	39886.44	-0.413503	2352.032	-0.594473	189.7815	0.502586	19077.83	-1.052596	-1954.172
0.909674	38596.45	-0.465137	1641.927	-0.646654	74.67324	0.450188	18156.25	-1.104706	-2306.6

0.857197	37273.6	-0.517624	983.2841	-0.699123	20.1137	0.397999	17236	-1.157049	-2559.24
0.80537	35906.52	-0.569771	440.973	-0.750949	-43.46825	0.345876	16297.38	-1.209204	-2711.327
0.75285	34572.18	-0.622276	173.3402	-0.803602	-133.8792	0.293334	15363.05	-1.261347	-2791.099
0.700447	33255.18	-0.674152	92.49267	-0.855526	-224.2386	0.240962	14428.6	-1.313998	-2805.776
0.648172	31882.73	-0.726572	28.20876	-0.907889	-359.9741	0.188902	13502.2	-1.366038	-2812.744
0.596058	30554.07	-0.77837	-63.06512	-0.96025	-535.631	0.136631	12577.24	-1.367947	-2352.871
0.543804	29247.73	-0.831047	-178.2313	-1.012695	-729.2169	0.084431	11653.21	-1.315546	-1631.993
0.491546	27872.88	-0.883142	-329.9573	-1.064742	-913.1427	0.032422	10730.26	-1.263492	-1136.7
0.43946	26487.9	-0.935851	-541.8842	-1.116938	-1044.911	-0.019825	9816.331	-1.211225	-782.7975
0.386899	25146.44	-0.987715	-786.0497	-1.168923	-1102.085	-0.072102	8892.629	-1.159138	-515.9891
0.334855	23788.06	-1.039672	-1039.965	-1.2215	-1092.084	-0.124103	7981.866	-1.106764	-319.7628
0.282372	22431.72	-1.092011	-1261.797	-1.273922	-1035.528	-0.176511	7064.154	-1.054446	-178.0252
0.229933	21079.54	-1.14442	-1434.743	-1.325737	-970.9351	-0.228596	6149.623	-1.002635	-64.61715
0.178004	19759.94	-1.196588	-1556.181	-1.375661	-900.1018	-0.2813	5244.811	-0.950173	16.96455
0.125791	18457.59	-1.248647	-1602.993	-1.355999	-599.4641	-0.333585	4341.531	-0.898054	71.73016
0.073493	17096.01	-1.301032	-1594.39	-1.303863	-343.5199	-0.385509	3459.343	-0.845945	125.6264
0.021412	15713.59	-1.353382	-1549.857	-1.251353	-183.3962	-0.43786	2588.798	-0.79359	161.3876
-0.030759	14332.08	-1.376978	-1342.548	-1.199304	-89.61073	-0.489666	1755.78	-0.741571	191.9067
-0.083251	12954.11	-1.328382	-876.7762	-1.146893	-31.63156	-0.542443	1002.945	-0.689402	215.7089
-0.135347	11596.98	-1.27628	-564.8363	-1.094902	9.944967	-0.59419	484.4944	-0.637385	236.5164
-0.187535	10248.27	-1.223958	-361.6098	-1.042883	29.52896	-0.64664	260.7501	-0.585099	269.779
-0.240063	8896.538	-1.171689	-210.9014	-0.990544	35.51814	-0.698484	141.6426	-0.533239	290.1937
-0.291889	7559.595	-1.11961	-111.2877	-0.938361	46.66575	-0.750845	-10.6823	-0.481141	326.8952
-0.344252	6231.92	-1.067227	-41.61354	-0.886342	56.40944	-0.803366	-231.7862	-0.428544	459.0372
-0.396391	4916.371	-1.015151	2.371547	-0.833896	62.38575	-0.855427	-508.0228	-0.376647	881.2103
-0.448623	3622.97	-0.96278	30.30819	-0.781709	73.3144	-0.907726	-833.9117	-0.324665	1648.696
-0.500898	2397.82	-0.91059	51.54082	-0.729534	70.53233	-0.959872	-1238.761	-0.272552	2557.732
		-0.85848	62.68199	-0.677631	84.04985			-0.220088	3571.077
		-0.806276	74.07432					-0.168378	4699.588
		-0.754083	84.01121					-0.115981	5956.365
								-0.064089	7311.572

B.1.4 Pac 3

B.1.4.1-Pac 3 Alodine

Pac 3 Alodine 1		Pac 3 Alodine 2		Pac 3 Alodine 3		Pac 3 Alodine 4		Pac 3 Alodine 5	
Volts	nano	Volts	nano	Volts	nano	Volts	nano	Volts	nano

	Amps		Amps		Amps		Amps		Amps
1.193267	11961.34	0.600033	2598.523	0.166458	5611.587	-1.145208	-6.625108	-1.121061	-637.2668
1.141005	11681.01	0.652112	2689.204	0.114174	5278.144	-1.093268	2.101068	-1.173086	-704.4165
1.088468	11384.68	0.704374	2856.122	0.06176	4908.521	-1.041237	-3.012278	-1.225301	-749.0907
1.036319	11173.55	0.756478	3040.164	0.009766	4542.948	-0.988847	-2.4842	-1.277979	-791.4529
0.983807	10799.17	0.808504	3195.284	-0.042338	4195.421	-0.936753	0.027394	-1.33002	-819.4217
0.93178	10370.34	0.860326	3411.771	-0.094671	3811.462	-0.884321	-0.288165	-1.377746	-818.5909
0.87945	10098.92	0.912671	3537.93	-0.146935	3417.921	-0.832257	2.764386	-1.351671	-667.7794
0.826923	9696.985	0.964761	3610.515	-0.199207	3027.297	-0.779931	1.154391	-1.299301	-503.6887
0.774803	9381.045	1.01695	3753.953	-0.251609	2635.456	-0.72803	0.896791	-1.247244	-370.5163
0.722464	8973.406	1.069038	3940.036	-0.303802	2239.732	-0.675455	1.038471	-1.195035	-270.381
0.670269	8594.509	1.121389	4088.027	-0.355865	1834.489	-0.623664	2.255628	-1.142805	-185.4183
0.618101	8257.201	1.173306	4153.748	-0.408147	1432.254	-0.57171	6.647696	-1.090264	-122.2614
0.56571	7949.64	1.225661	4210.49	-0.460704	1019.85	-0.519509	-0.133606	-1.038034	-73.81989
0.513507	7591.988	1.277637	4392.014	-0.512529	619.9853	-0.467158	1.894989	-0.986073	-34.04012
0.4613	7210.953	1.329552	4604.135	-0.565002	275.8068	-0.41498	18.54878	-0.933833	-7.024387
0.40896	6892.818	1.380524	4815.16	-0.617137	81.55114	-0.362849	78.09931	-0.881834	12.95888
0.35683	6571.127	1.364178	4730.719	-0.669211	36.3811	-0.310712	184.9901	-0.829554	22.94729
0.304374	6239.223	1.311847	4904.947	-0.721624	12.26336	-0.258686	315.7798	-0.777607	34.10778
0.2521	5869.091	1.259442	5017.266	-0.773531	-19.16376	-0.206437	485.834	-0.725208	38.00397
0.199952	5501.689	1.206839	4990.869	-0.825955	-62.16352	-0.154459	675.865	-0.672969	40.79893
0.147666	5167.756	1.154596	4975.065	-0.878128	-118.127	-0.102242	869.5475	-0.620799	44.00604
0.095607	4782.806	1.102567	4787.063	-0.930704	-192.7277	-0.050281	1065.072	-0.568702	56.12608
0.043127	4411.205	1.050083	4718.444	-0.982682	-275.1402	0.002092	1264.518	-0.516555	52.78373
-0.009186	4030.918	0.997834	4728.381	-1.034897	-357.6557	0.054057	1448.657	-0.464391	61.36823
-0.061109	3622.062	0.945558	4753.774	-1.087126	-420.3747	0.10637	1648.206	-0.412451	104.8896
-0.113327	3311.461	0.893201	4740.495	-1.139499	-468.0048	0.15849	1834.07	-0.36037	265.0198
-0.165772	2953.237	0.840936	4636.045	-1.192091	-491.0728	0.210302	2039.171	-0.30763	500.369
-0.218117	2592.372	0.788498	4606.839	-1.243955	-500.4494	0.262554	2233.717	-0.255963	788.7966
-0.270212	2224.553	0.736491	4473.132	-1.296142	-493.2946	0.314962	2435.597	-0.203575	1126.162
-0.322479	1869.439	0.683997	4323.873	-1.348621	-485.4636	0.367141	2617.907	-0.151445	1514.795
-0.374802	1524.153	0.631713	4265.378	-1.378941	-438.2714	0.418958	2809.806	-0.099434	1919.452
-0.427053	1173.611	0.579769	4186.063	-1.333044	-299.1484	0.470927	3007.674	-0.047305	2339.455
-0.479237	817.8022	0.52721	4060.355	-1.280649	-200.8163	0.523585	3217.721	0.004748	2776.62
-0.531341	491.7523	0.47483	3950.933	-1.228262	-131.4964	0.5757	3403.714	0.056728	3250.687
-0.58358	225.9227	0.42294	3938.439	-1.176078	-85.7081	0.627484	3624.104	0.109161	3709.53
-0.635858	88.4548	0.370501	3829.964	-1.124161	-49.05172	0.679687	3866.981	0.161345	4169.558
-0.688045	36.62582	0.318338	3730.093	-1.072056	-25.33326	0.731852	4033.603	0.213366	4608.198
-0.740382	-17.90152	0.266157	3567.045	-1.019823	-4.235875	0.784071	4249.484	0.265323	5040.528
-0.79252	-85.45694	0.213418	3421.907	-0.967702	2.584067	0.835873	4457.792	0.317271	5471.518
-0.844801	-172.7509	0.161484	3238.966	-0.915382	12.9782	0.888349	4697.817	0.369747	5919.69

-0.897042	-281.2839	0.109333	3072.255	-0.863401	18.98026	0.9404	4878.233	0.422077	6345.682
-0.949167	-415.3515	0.057119	2912.144	-0.810956	21.9169	0.992454	5067.969	0.473883	6792.817
-1.001629	-541.0213	0.00496	2769.704	-0.75893	21.1441	1.044652	5236.329	0.525931	7320.601
-1.053742	-677.2913	-0.047584	2623.484	-0.706755	25.44601	1.096683	5402.732	0.578042	7742.137
-1.105909	-792.6571	-0.099856	2395.199	-0.654289	22.27109	1.149061	5614.305	0.630359	8209.475
-1.158219	-896.2249	-0.151804	2181.018	-0.60226	26.0256	1.200911	5799.571	0.682366	8758.42
-1.21031	-968.7262	-0.204477	1957.641	-0.550327	33.3221	1.253224	6179.653	0.734521	9231.689
-1.262663	-1031.078	-0.256403	1717.893	-0.498201	35.8981	1.305267	6308.871	0.786561	9670.89
-1.315142	-1064.843	-0.308505	1478.834	-0.446004	42.24148	1.357465	6502.754	0.838837	10084.66
-1.367146	-1066.607	-0.36062	1212.58	-0.393634	98.28221	1.383703	6613	0.89087	10428.25
-1.366736	-913.6	-0.413354	942.5963	-0.341616	280.4629	1.336182	6542.649	0.942757	10833.61
-1.314316	-693.4557	-0.465322	664.814	-0.28944	545.1655	1.28413	6443.989	0.995092	11289.4
-1.262071	-525.0115	-0.517475	406.3903	-0.237321	887.0578	1.231629	6282.435	1.047318	11716.68
-1.209833	-385.7404	-0.569762	165.58	-0.185026	1290.24	1.179243	6088.102	1.09949	12094.48
-1.157657	-275.5717	-0.622055	40.23221	-0.133126	1755.773	1.126971	5906.822	1.151535	12584.93
-1.105355	-188.0201	-0.674379	16.67475	-0.080809	2255.432	1.074619	5701.876	1.203731	13204.47
-1.053461	-117.3349	-0.726268	11.32312	-0.02902	2767.128	1.02247	5479.259	1.256029	13903.39
-1.000989	-62.71092	-0.778774	-6.05839	0.023338	3291.704	0.970255	5326.895	1.307743	14393.33
-0.948982	-23.33686	-0.831082	-18.08828	0.075428	3793.301	0.917692	5140.856	1.359973	14899.63
-0.896652	3.794783	-0.883081	-39.74594	0.127561	4284.685	0.865675	5012.907	1.382767	15215.01
-0.844542	21.2407	-0.935414	-71.39846	0.179544	4808.733	0.813118	4823.133	1.333733	14937.13
-0.792465	32.18867	-0.987725	-93.96415	0.231994	5338.165	0.761051	4658.636	1.281194	14684.64
-0.740127	46.86539	-1.039955	-123.0342	0.283888	5910.281	0.70871	4492.291	1.228689	14449.66
-0.688038	51.86926	-1.09232	-131.8892	0.335793	6434.232	0.656238	4333.436	1.176565	14122.03
-0.635854	60.00939	-1.144337	-129.9315	0.387988	6919.795	0.60392	4151.957	1.124468	13737.31
-0.583821	62.29559	-1.196947	-111.8737	0.440236	7446.773	0.551685	3947.842	1.072279	13291.25
-0.53173	65.31594	-1.248612	-97.44175	0.492307	7924.782	0.499666	3789.553	1.019977	12939.28
-0.479352	73.48828	-1.30108	-90.0744	0.544677	8481.77	0.447161	3592.94	0.967383	12644.96
-0.427206	105.598	-1.353575	-86.13958	0.596707	9066.78	0.39501	3403.502	0.915257	12359.18
-0.375085	222.0136	-1.376949	-75.07569	0.648555	9571.521	0.342737	3241.407	0.862727	11965.26
-0.322583	426.1611	-1.328026	-37.29231	0.700829	10045.76	0.290591	3078.54	0.810584	11565.87
-0.270642	658.8828	-1.275711	-22.01023	0.752962	10601.01	0.23831	2890.492	0.758201	11189.67
-0.218547	908.9216	-1.223538	-5.472352	0.805135	11139.37	0.186265	2715.801	0.705923	10765.93
-0.166729	1204.723	-1.171299	1.051351	0.85721	11688.86	0.133779	2535.913	0.653705	10285.7
-0.114659	1558.182	-1.119103	2.500347	0.9093	12198.54	0.081622	2343.093	0.601589	9888.955
-0.062253	1930.149	-1.066793	3.588704	0.961505	12689.47	0.029121	2151.987	0.549253	9482.404
-0.010168	2312.819	-1.0148	4.883141	1.013671	13220.04	-0.023101	1981.849	0.497081	9091.136
0.042029	2688.193	-0.962726	5.862018	1.065743	13758.13	-0.074846	1799.024	0.444753	8631.623
0.094048	3153.476	-0.910372	4.483862	1.117882	14403.82	-0.126973	1603.854	0.392119	8172.96
0.146092	3596.534	-0.858479	4.741461	1.170069	14946.78	-0.179733	1418.093	0.340034	7689.4
0.198334	4050.888	-0.806132	7.388294	1.22204	15462.24	-0.231799	1225.885	0.287987	7274.136

0.250299	4499.453	-0.753823	11.98	1.274118	16034.13	-0.284167	1044.103	0.235525	6850.61
0.302501	4948.333	-0.701776	4.677061	1.326403	16529.86	-0.336168	849.8412	0.18339	6390.749
0.354839	5437.051	-0.649392	7.027655	1.377728	17023.88	-0.388545	666.8941	0.131229	5978.725
0.406797	5911.524	-0.597396	10.14461	1.367338	17083.4	-0.440821	482.5045	0.078965	5545.545
0.459208	6355.394	-0.545282	11.19432	1.314836	16794.58	-0.493101	304.7288	0.026624	5095.879
0.511077	6825.217	-0.49293	7.150015	1.262581	16488.4	-0.545458	144.8175	-0.025489	4650.625
0.563064	7285.058	-0.440956	17.55703	1.210365	16098.34	-0.597712	39.43365	-0.077921	4236.791
0.615268	7749.034	-0.388924	61.35535	1.157809	15680.81	-0.649625	16.38495	-0.130109	3792.728
0.667354	8230.662	-0.33656	171.7753	1.105678	15350.41	-0.701778	3.807663	-0.182408	3355.582
0.719527	8660.332	-0.284633	336.0915	1.053393	14978.11	-0.75421	-8.106305	-0.234525	2915.531
0.771729	9148.297	-0.232543	553.4796	1.001094	14696	-0.806467	-28.16041	-0.286865	2488.541
0.823885	9611.224	-0.180258	839.7755	0.948675	14334.38	-0.858601	-57.10169	-0.339009	2058.047
0.875975	10044.85	-0.12813	1174.912	0.896493	13957.54	-0.911064	-102.0657	-0.39131	1623.953
0.928003	10526.19	-0.076062	1519.767	0.844246	13534.58	-0.963264	-156.7025	-0.443441	1202.842
0.980165	11004.15	-0.023689	1844.362	0.791876	13101.05	-1.015647	-206.3354	-0.495589	811.5104
1.032174	11477.57	0.028229	2183.614	0.739724	12628.3	-1.067711	-251.5441	-0.547973	448.7397
1.08446	11989.93	0.080354	2523.091	0.687474	12194.6	-1.119798	-285.8692	-0.600041	194.8562
1.136425	12475.69	0.132269	2822.422	0.635136	11763.86	-1.172291	-322.5835	-0.652347	86.67092
1.188783	12994.76	0.184603	3129.506	0.582673	11262.68	-1.224321	-335.3476	-0.704676	40.68945
1.24109	13469.28	0.23666	3453.843	0.530613	10857.14	-1.276789	-356.651	-0.75696	-21.23099
1.292758	13873.5	0.288926	3767.097	0.478137	10403.11	-1.328842	-353.1992	-0.809159	-106.2001
1.344887	14346.25	0.341188	4099.149	0.426139	9999.06	-1.37731	-356.6188	-0.861291	-208.2481
1.385882	14876.38	0.393157	4407.953	0.373829	9500.34	-1.352729	-267.4702	-0.913549	-338.0974
1.348792	14898.34	0.445352	4740.076	0.321542	8985.797	-1.300366	-182.7586	-0.965799	-491.7039
1.29653	14697.7	0.497378	5090.74	0.269242	8483.387	-1.2479	-119.9108	-1.018057	-648.0924
1.244126	14453.6	0.54966	5415.767	0.217028	7983.862	-1.195917	-76.73076	-1.07059	-792.8439
1.191909	14055.1	0.601505	5738.352	0.164717	7513.401	-1.143513	-49.14832	-1.122268	-921.9848
1.139493	13751.76	0.653782	6021.113	0.112316	6992.148	-1.091442	-27.64521	-1.174667	-1018.72
1.087226	13443.37	0.705785	6350.538	0.060141	6493.854	-1.039141	-16.6908	-1.227056	-1094.196
1.034728	13035.45	0.757864	6698.491	0.007943	5967.616	-0.986983	-0.017686	-1.27933	-1143.945
0.98247	12669.64	0.810149	7099.348	-0.044201	5443.31			-1.331497	-1192.264
0.930262	12259.18	0.862411	7402.55	-0.096483	4922.096			-1.378407	-1187.647
0.87803	11863.08	0.914492	7764.915	-0.148697	4386.766			-1.349872	-953.4957
0.825646	11534.19	0.966482	8118.735	-0.201133	3863.742			-1.297786	-713.1169
0.773307	11090.27	1.018783	8478.963	-0.253089	3319.254			-1.245554	-532.3273
0.721159	10707.99	1.070646	8979.041	-0.305343	2809.387			-1.193217	-389.7654
0.668869	10312.6	1.122888	9447.467	-0.357592	2276.414			-1.141028	-268.4941
0.616654	9866.157	1.174953	9741.685	-0.409703	1756.701			-1.089	-176.4732
0.5643	9495.716	1.227069	10134.35	-0.462175	1241.714			-1.036703	-101.0868
0.511928	9068.403	1.279226	10505.16	-0.514493	767.0165			-0.984549	-45.47108
0.459546	8618.685	1.33135	10901.39	-0.566418	353.5825			-0.932517	-4.216555

0.407384	8188.821	1.381284	11409.56	-0.61876	128.2153			-0.879861	19.92694
0.35525	7766.222	1.362177	11476.34						
0.303147	7324.6	1.309985	11210.19						
0.250899	6875.423	1.25747	11077.42						
0.198481	6443.126	1.205454	10808.16						
0.146081	6012.142	1.152967	10560.49						
0.09405	5604.626	1.100766	10339.47						
0.041838	5171.266	1.048273	10255.67						
-0.01042	4750.657	0.99601	10022.26						
-0.062665	4335.935	0.943822	9845.298						
-0.115003	3923.46	0.891441	9662.306						
-0.167181	3485.888	0.838983	9330.034						
-0.219541	3060.192	0.786697	9031.424						
-0.271625	2622.396	0.734415	8910.23						
-0.323808	2195.714	0.682297	8714.518						
-0.376065	1751.291	0.630114	8410.518						
-0.428339	1336.794	0.577805	8162.727						
-0.48074	940.4195	0.525656	7831.002						
-0.533031	565.986	0.47338	7577.833						
-0.584869	260.4796	0.420976	7246.077						
-0.637094	103.1766	0.368781	6918.526						
-0.689434	42.24148	0.316492	6639.842						
-0.741702	-21.12151	0.264253	6279.872						
-0.793662	-112.7496	0.212002	5941.36						
-0.846148	-221.4114	0.159706	5583.013						
-0.898351	-353.9913	0.107405	5183.457						
-0.950542	-512.666	0.055245	4807.387						
-1.002989	-683.6218	0.003006	4451.649						
-1.05513	-855.8527	-0.049227	4086.997						
-1.107439	-1007.791	-0.10152	3714.218						
-1.159741	-1124.909	-0.153625	3329.757						
-1.211839	-1234.91	-0.205751	2947.937						
-1.264043	-1323.582	-0.258068	2546.706						
-1.316377	-1378.148	-0.31044	2152.599						
-1.368385	-1405.943	-0.362643	1740.143						
-1.365	-1245.549	-0.414897	1341.321						
-1.312821	-967.2579	-0.467135	951.0713						
-1.260595	-747.0749	-0.519474	576.4188						
-1.208465	-554.6998	-0.571516	260.0803						
-1.156253	-406.6704	-0.62384	85.20261						
-1.10398	-285.7597	-0.675994	36.62582						

-1.051585	-189.2952	-0.727825	18.23323						
-0.999555	-104.3776	-0.780496	-17.9788						
-0.947646	-45.07181	-0.832924	-52.08495						
-0.895195	-6.592909	-0.884921	-107.6169						
-0.843119	22.70257	-0.937358	-176.3122						
-0.790833	41.9388	-0.989314	-255.7558						
-0.738887	56.17116	-1.041606	-323.1309						
-0.686617	66.15958	-1.093929	-373.717						
-0.634442	76.89503	-1.146306	-397.9893						
-0.582406	85.16397	-1.198457	-392.4187						
-0.530084	91.84867	-1.25045	-371.946						
-0.477818	100.3044	-1.302771	-349.4061						
-0.425641	138.9571	-1.355084	-326.0998						
-0.373541	276.0193	-1.375892	-265.3643						
-0.321458	537.386	-1.326385	-161.0044						
-0.269283	830.5405	-1.274107	-94.42783						
-0.217226	1154.781	-1.221699	-54.1715						
-0.165024	1515.014	-1.169516	-27.25881						
-0.11308	1917.855	-1.117498	-7.990385						
-0.060885	2344.774	-1.065069	1.032031						
-0.008756	2790.93	-1.012921	12.28912						
0.043375	3277.761	-0.960904	16.08871						
0.095388	3764.585	-0.908496	17.71803						
0.147665	4260.4	-0.856394	18.6647						
0.1995	4786.837	-0.804526	22.32261						
0.251751	5318.02	-0.751909	24.20953						
0.304035	5839.125	-0.699922	23.57841						
0.356133	6347.228	-0.647721	29.25204						
0.408321	6906.928	-0.59579	27.12684						
0.460282	7384.801	-0.543558	31.71855						
0.512502	7908.269	-0.49129	33.07739						
0.56458	8401.27	-0.439179	48.41098						
0.616602	8928.893	-0.38692	130.9394						
0.668819	9459.684	-0.334867	319.9142						
0.721131	9970.118	-0.282658	571.4986						
0.772932	10492.36	-0.230576	891.4435						
0.825255	10983.71	-0.178387	1275.363						
0.877173	11490.07	-0.126459	1703.79						
0.929634	12104.47	-0.074255	2149.565						
0.981534	12586.05	-0.022007	2599.089						
1.033731	13158.25	0.029761	3071.714						

1.085712	13633.1	0.082112	3538.439						
1.137996	14073.99	0.134207	4030.57						
1.190156	14590.87	0.186318	4524.201						
1.242184	15154.23	0.238608	5041.481						
1.294422	15711.44	0.290515	5505.25						
1.346454	16292.75	0.342593	5993.782						
1.385951	16765.51	0.394714	6466.168						
1.347303	16586.92	0.446795	6940.094						
1.294739	16277.33	0.499334	7387.892						
1.242521	15890.52	0.551246	7814.065						
1.190342	15482.28	0.60348	8304.529						
1.137927	15082.79	0.655421	8828.964						
1.085627	14652.31	0.707599	9262.008						
1.03335	14226.77	0.759701	9683.236						
0.980963	13822.72	0.81182	10132.03						
0.928775	13431.9	0.864028	10526.19						
0.876616	13103.9	0.916172	10950.47						
0.824129	12653	0.96828	11542.33						
0.771801	12341.85	1.020278	12130.16						
0.719666	11900.6	1.072512	12737.12						
0.667354	11418.74	1.124617	13129.14						
0.61495	11005.69	1.176753	13753.75						
0.562579	10575.59	1.228778	14355.01						
0.510488	10151.24	1.280866	14831.61						
0.458194	9701.371	1.333049	15184.44						
0.406003	9238.541	1.382421	15694.32						
0.353696	8777.283	1.360634	15769.03						
0.301394	8304.001	1.308225	15493.08						
0.249134	7808.314	1.255821	15203.32						
0.19698	7329.32	1.203703	14886.31						
0.144619	6853.044	1.151151	14553.96						
0.092477	6345.502	1.098951	14206.03						
0.040032	5873.038	1.046667	13805.11						
-0.012064	5397.78	0.994326	13442.01						
-0.064157	4921.459	0.942098	13048.71						
-0.116178	4465.346	0.889758	12568.55						
-0.168829	3962.093	0.837378	12177.45						
-0.22097	3457.952	0.785101	11722.75						
-0.273281	2971.636	0.732835	11274.51						
-0.325468	2486.988	0.680756	10845.8						
-0.377777	1990.607	0.628193	10463.82						

-0.429941	1519.548	0.576094	10080.93						
-0.482063	1056.455	0.523692	9667.213						
-0.534265	640.8057	0.471621	9222.711						
-0.586701	296.6788	0.419152	8739.512						
-0.638829	123.5849	0.366998	8247.02						
-0.691065	55.59157	0.314739	7833.514						
-0.743084	-25.6617	0.262589	7400.849						
-0.795324	-139.6108	0.210172	6947.487						
-0.847801	-273.015	0.157885	6483.826						
-0.899914	-428.2572	0.105708	6023.702						
-0.952238	-618.7841	0.053436	5580.907						
-1.004443	-821.6821	0.001331	5096.762						
-1.056694	-1025.012	-0.051033	4648.042						
-1.108978	-1222.204	-0.103128	4193.212						
-1.16137	-1369.66	-0.155499	3755.885						
-1.213588	-1491.382	-0.207702	3287.054						
-1.265535	-1623.956	-0.260013	2844.756						
-1.317912	-1691.485	-0.311914	2398.87						
-1.370085	-1745.214	-0.364342	1942.243						
-1.363548	-1518.359	-0.416736	1498.412						
-1.311307	-1182.894	-0.468918	1064.995						
-1.259049	-936.7002	-0.521195	653.1383						
-1.206799	-712.5051	-0.57344	311.8256						
-1.154708	-532.0246	-0.625584	128.9494						
-1.102511	-377.6261	-0.677666	67.97565						
-1.050137	-248.4658	-0.73005	23.54621						
-0.997919	-148.7362	-0.782186	-37.58855						
-0.945986	-72.21633	-0.834407	-113.6576						
-0.893713	-15.918	-0.886899	-207.2048						
-0.841577	20.98954	-0.938967	-324.728						
-0.789379	49.0743	-0.99117	-449.6379						
-0.737223	72.0586	-1.043612	-566.8971						
-0.685073	86.05912	-1.095782	-657.688						
-0.632791	99.72477	-1.147722	-712.8014						
-0.580648	104.426	-1.199982	-718.2882						
-0.528438	115.8054	-1.252428	-705.9557						
-0.476425	131.1583	-1.304635	-677.1432						
-0.424325	175.1627	-1.356962	-644.0288						
-0.371958	340.2968	-1.374809	-545.7933						
-0.319866	622.4196	-1.324855	-353.2894						
-0.267941	965.645	-1.272303	-232.2435						

-0.215705	1320.127	-1.220064	-139.8941						
-0.163757	1726.136	-1.167935	-86.48733						
-0.111418	2157.132	-1.115713	-42.70833						
-0.059353	2623.793	-1.063432	-11.27478						
-0.007145	3146.527	-1.011198	10.82725						
0.044734	3688.594	-0.959195	19.87542						
0.097008	4196.992	-0.906871	27.91252						
0.14892	4747.946	-0.854818	38.22937						
0.201406	5305.978	-0.802585	43.2912						
0.2534	5875.241	-0.750351	50.59414						
0.30567	6474.54	-0.69826	49.18378						
0.357674	7101.879	-0.646225	60.99471						
0.40979	7651.906	-0.594016	62.12815						
0.461821	8251.341	-0.541776	64.94886						
0.513964	8867.893	-0.489561	67.88549						
0.566275	9460.792	-0.43725	92.93059						
0.618292	10061.59	-0.385494	208.1226						
0.670357	10644.55	-0.333073	437.1155						
0.722515	11262.23	-0.281197	730.5405						
0.774654	11833.71	-0.228898	1081.809						
0.826885	12423.7	-0.176869	1528.274						
0.878968	13031.88	-0.12461	2013.572						
0.931007	13671.31	-0.072613	2549.469						
0.983131	14220.43	-0.020658	3115.853						
1.035306	14859.59	0.031629	3685.193						
1.087274	15475.15	0.083705	4234.724						
1.139516	16090.41	0.135946	4786.367						
1.191696	16716.91	0.187881	5336.941						
1.243789	17310.73	0.240142	5856.223						
1.295969	17926.14	0.292036	6376.047						
1.347959	18475.27	0.344271	6884.31						
1.385839	18993.95	0.396682	7427.717						
1.345571	18704.42	0.448689	7982.716						
1.293252	18310.36	0.500566	8504.523						
1.240982	17934.86	0.552924	9051.826						
1.188628	17513.1	0.604999	9622.97						
1.136287	17019.62	0.657044	10170.16						
1.08383	16608.75	0.709142	10850.12						
1.031646	16174.06	0.76143	11352.84						
0.979297	15594.88	0.813763	11927.96						
0.927009	15133.75	0.865586	12484.92						

0.874843	14691.86	0.91773	12910.86						
0.822466	14221.36	0.970016	13469.15						
0.770193	13661.19	1.021914	14059.79						
0.717693	13105.92	1.074154	14654.86						
0.665566	12702.49	1.126288	15248.61						
0.613451	12223.31	1.178667	15792.45						
0.561015	11710.97	1.230615	16332.23						
0.508738	11160.09	1.282657	17081.97						
0.456664	10622.38	1.334743	17605.42						
0.404059	10116.24	1.383116	18223.65						
0.351881	9566.916	1.358773	18101.47						
0.299953	9005.877	1.306552	17662.85						
0.247453	8502.623	1.254308	17295.33						
0.195212	7948.133	1.201891	16829.32						
0.142934	7383.152	1.149564	16366.11						
0.090843	6824.876	1.097184	15919.04						
0.038373	6299.643	1.045046	15513.21						
-0.013564	5803.113	0.992745	15045.96						
-0.066047	5287.939	0.940347	14578.7						
-0.118296	4742.665	0.888024	14130.23						
-0.1703	4208.79	0.835875	13622.36						
-0.222951	3680.164	0.783525	13148.36						
-0.274795	3143.944	0.731366	12671.25						
-0.327235	2638.953	0.678934	12198.22						
-0.37942	2110.024	0.626725	11749.43						
-0.431536	1605.94	0.574475	11279.33						
-0.483758	1126.896	0.522118	10772.99						
-0.536118	676.6893	0.46986	10284.9						
-0.588247	320.7192	0.417679	9762.035						
-0.640509	146.0669	0.365251	9244.859						
-0.692681	61.39399	0.313296	8738.43						
-0.745151	-29.54501	0.260818	8199.138						
-0.797226	-156.3805	0.208473	7695.086						
-0.849323	-313.5547	0.156273	7174.123						
-0.901674	-496.2699	0.103969	6682.571						
-0.953868	-715.841	0.051865	6166.245						
-1.006207	-950.237	-0.00051	5680.682						
-1.058163	-1183.165	-0.052623	5179.432						
-1.110726	-1415.287	-0.104847	4673.526						
-1.162827	-1624.258	-0.157068	4161.546						
-1.215137	-1825.314	-0.209532	3660.47						

-1.267492	-1986.063	-0.261501	3145.934						
-1.319463	-2092.38	-0.313885	2651.762						
-1.371517	-2183.931	-0.36609	2145.231						
-1.361736	-1936.031	-0.418316	1663.488						
-1.309661	-1543.121	-0.470537	1190.703						
-1.2572	-1229.475	-0.522536	744.4508						
-1.205263	-956.5225	-0.574814	367.3833						
-1.153036	-728.7017	-0.627308	162.199						
-1.100849	-523.0151	-0.67947	89.07304						
-1.048548	-359.6778	-0.731567	24.78913						
-0.996351	-225.9001	-0.783911	-69.56306						
-0.944274	-117.9531	-0.836282	-180.5562						
-0.892048	-38.72842	-0.888206	-314.3983						
-0.839688	14.55599	-0.940665	-479.5517						
-0.787663	55.65597	-0.992777	-653.6115						
-0.735639	84.73893	-1.044958	-820.5809						
-0.683377	102.8675	-1.097252	-955.4727						
-0.631007	120.191	-1.149675	-1056.052						
-0.579104	133.3608	-1.201841	-1117.445						
-0.526945	140.5221	-1.25419	-1126.667						
-0.474643	163.7575	-1.306157	-1117.277						
-0.422472	220.6226	-1.358486	-1084.111						
-0.370398	400.0083	-1.373956	-929.0173						
-0.318185	716.5915	-1.322881	-646.1347						
-0.266219	1084.057	-1.270765	-453.444						
-0.214056	1492.79	-1.218605	-312.2216						
-0.16202	1948.619	-1.166262	-208.2996						
-0.109759	2479.351	-1.114092	-123.9745						
-0.05762	3014.469	-1.061948	-63.27764						
-0.005494	3579.288	-1.009803	-20.66427						
0.046314	4146.232	-0.957621	13.7188						
0.09868	4750.264	-0.905384	36.82546						
0.150804	5343.774	-0.853268	52.25565						
0.202818	5937.921	-0.800771	62.79791						
0.255061	6524.54	-0.74899	73.19848						
0.30707	7124.818	-0.696632	80.5143						
0.359211	7721.31	-0.644519	96.78814						
0.411448	8364.176	-0.59236	97.80565						
0.463524	8976.749	-0.54028	106.9247						
0.515748	9572.313	-0.488075	111.0463						
0.567815	10233.39	-0.435791	139.5625						

0.619999	10872.66	-0.383525	257.3369						
0.672093	11499.27	-0.331524	520.8932						
0.724157	12096.68	-0.279406	851.6315						
0.776198	12715.21	-0.227393	1226.715						
0.828473	13294.38	-0.175027	1663.939						
0.88049	13886.39	-0.123066	2183.311						
0.932851	14525.83	-0.070982	2748.639						
0.984888	15121.52	-0.018964	3321.109						
1.036744	15760.91	0.033025	3935.606						
1.088956	16339.17	0.085402	4546.117						
1.141061	17023.5	0.137544	5153.923						
1.193345	17690.58	0.189722	5787.393						
1.245415	18345.14	0.241852	6407.744						
1.297586	18981.76	0.29382	7056.323						
1.349517	19608.12	0.345899	7689.941						
1.385783	20172.84	0.398274	8280.314						
1.343883	19880.34	0.450329	8900.853						
1.291456	19503.23	0.502626	9521.933						
1.239243	19010.03	0.554613	10116.33						
1.186769	18577.82	0.606689	10701.68						
1.134683	18189.41	0.6586	11309.78						
1.082188	17716.72	0.71104	11951.61						
1.029808	17120.08	0.763165	12573.14						
0.977561	16652.29	0.815273	13097.76						
0.92532	16121.06	0.867353	13706.71						
0.873038	15608.56	0.91948	14303.14						
0.820911	15167.21	0.971555	14916.17						
0.768403	14656.41	1.023699	15476.44						
0.716032	14037.41	1.075738	16080.96						
0.663975	13479.44	1.127792	16688.76						
0.611724	12940.62	1.18033	17353.41						
0.559262	12368.19	1.232125	18008.66						
0.507231	11813.25	1.284258	18623.68						
0.454873	11291.54	1.33636	19275.7						
0.402575	10741.44	1.383707	19872.6						
0.350353	10210.44	1.357313	19710.1						
0.298145	9671.933	1.30513	19357.74						
0.245853	9156.392	1.252608	18920.54						
0.193656	8613.501	1.200201	18491.98						
0.14125	8020.924	1.147741	17986.55						
0.08899	7428.947	1.095477	17476.16						

0.036778	6849.09	1.043377	17054.73						
-0.015306	6249.166	0.991187	16609.36						
-0.067615	5673.308	0.938726	16059.64						
-0.119613	5111.471	0.886532	15614.96						
-0.172409	4556.691	0.834243	15112.76						
-0.224352	3967.877	0.781749	14591.73						
-0.276563	3424.477	0.729467	14046.07						
-0.328779	2858.305	0.677377	13446.77						
-0.381011	2298.239	0.624967	12851.19						
-0.433266	1749.713	0.572733	12296.86						
-0.485595	1220.926	0.520354	11781.07						
-0.537701	729.7677	0.468292	11305.81						
-0.59002	346.2409	0.415851	10691.78						
-0.642158	157.2403	0.363718	10164.17						
-0.694306	70.24897	0.311428	9631.786						
-0.746602	-39.7395	0.259293	9090.756						
-0.798811	-192.3928	0.206916	8555.747						
-0.851029	-360.5215	0.154669	7981.447						
-0.903545	-575.3206	0.102136	7379.642						
-0.955526	-820.5487	0.050307	6835.077						
-1.007944	-1091.975	-0.002181	6284.47						
		-0.05416	5692.042						
		-0.106494	5130.198						
		-0.158638	4563.994						
		-0.210797	4005.28						
		-0.263089	3476.525						
		-0.315295	2900.062						
		-0.367694	2340.434						
		-0.419848	1814.847						
		-0.472264	1292.236						
		-0.52448	803.3187						
		-0.576641	402.7968						
		-0.628721	185.9304						
		-0.680967	104.7415						
		-0.73326	17.52483						

B.1.4.2-Pac 3 Anodize Type II

Pac 3 Anodize Type II 1		Pac 3 Anodize Type II 2		Pac 3 Anodize Type II 3		Pac 3 Anodize Type II 4		Pac 3 Anodize Type II 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-0.915935	-55.93606	-0.844722	-12.00249	1.27814	492.4543	-0.523729	67.47333	-1.30366	-40.10014
-0.967957	-72.30649	-0.896886	-15.40925	1.225805	480.5789	-0.575802	34.84838	-1.251637	-25.3397
-1.02029	-90.86652	-0.949355	-7.713466	1.173587	455.2634	-0.627994	13.73812	-1.199426	-11.04938
-1.072553	-104.5644	-1.001555	-10.0705	1.121083	439.9555	-0.680604	3.118585	-1.146656	-6.17431
-1.124853	-113.4322	-1.053732	-6.985748	1.068937	430.6626	-0.732532	-0.037006	-1.094696	-2.658079
-1.177228	-112.1635	-1.105936	-8.782503	1.016512	421.1314	-0.784868	-9.040102	-1.042594	-1.608362
-1.229309	-109.8774	-1.158094	-7.172507	0.964352	401.6247	-0.837228	-19.30544	-0.990576	0.606992
-1.281592	-100.6489	-1.210492	-7.971065	0.911979	371.8269	-0.889111	-27.93501	-0.938284	2.648467
-1.333927	-98.58162	-1.262436	-6.528509	0.859724	365.8828	-0.941426	-44.84641	-0.886196	2.358667
-1.379085	-86.68697	-1.314764	-11.86082	0.807311	360.8532	-0.993885	-60.62436	-0.833927	2.513227
-1.347875	-60.55352	-1.367004	-11.15886	0.75538	347.6448	-1.045902	-78.41804	-0.781824	3.273145
-1.295411	-40.17098	-1.366862	-9.040102	0.702872	333.7473	-1.098261	-83.79542	-0.729578	10.00937
-1.243488	-27.85129	-1.314556	-9.374981	0.650707	324.4866	-1.150362	-91.28512	-0.677413	10.60185
-1.19156	-18.02388	-1.262309	-3.823716	0.598322	316.3787	-1.202716	-94.51155	-0.625129	7.323894
-1.138646	-9.336341	-1.209906	-7.146747	0.54585	297.2004	-1.254951	-84.84514	-0.573129	5.482059
-1.086992	-4.841233	-1.15793	-3.591877	0.493765	289.2921	-1.307418	-81.67023	-0.521144	4.863821
-1.034486	-1.885281	-1.105512	-0.719644	0.441375	274.5445	-1.359562	-71.4693	-0.468968	6.035897
-0.982743	0.445993	-1.053388	-3.218358	0.3892	261.993	-1.373338	-55.37578	-0.416712	10.64693
-0.930088	1.44419	-1.001172	-1.492442	0.336953	249.9567	-1.321994	-35.41827	-0.364494	24.58949
-0.878129	3.170105	-0.94907	-0.094966	0.284928	227.9191	-1.269671	-24.26422	-0.312097	42.89836
-0.825809	-0.957924	-0.897022	1.746869	0.232375	225.459	-1.217722	-16.99348	-0.260053	68.77421
-0.773558	3.846303	-0.844571	1.044911	0.180149	210.808	-1.165393	-9.658341	-0.208134	96.14414
-0.721613	2.352228	-0.792683	-2.020521	0.127983	182.1823	-1.113515	-6.695948	-0.155937	121.5434
-0.66931	3.356865	-0.740556	2.030228	0.07577	176.1416	-1.060984	-8.479824	-0.103705	156.783
-0.61714	3.157225	-0.688292	-0.835564	0.02343	162.4309	-1.009052	2.010908	-0.051896	209.9064
-0.56486	5.874898	-0.636053	-0.133606	-0.028664	146.7431	-0.956688	-1.595482	0.000557	258.5927
-0.512924	8.083812	-0.583896	0.684272	-0.081013	134.4814	-0.904379	0.851711	0.052436	308.8375
-0.460515	7.736053	-0.531834	1.19947	-0.133356	121.595	-0.852341	2.487467	0.10483	355.8171
-0.40863	18.64538	-0.479561	1.785509	-0.185381	100.7294	-0.800117	3.711064	0.157275	409.0178
-0.356394	38.08125	-0.427475	0.491072	-0.237628	76.43779	-0.748109	4.406582	0.209034	458.3095
-0.304331	70.64825	-0.375324	3.202305	-0.290081	28.18944	-0.695609	1.656709	0.26118	496.6467
-0.252158	103.8592	-0.323071	1.579429	-0.342281	-46.714	-0.643576	3.917143	0.31326	539.1957
-0.199984	157.5494	-0.271117	5.829818	-0.394695	-118.8869	-0.591387	1.22523	0.365501	575.0084
-0.147795	200.6779	-0.218674	3.543624	-0.446594	-163.2455	-0.539339	1.33471	0.417468	627.1852

-0.095497	263.0685	-0.166805	1.862789	-0.499148	-59.54245	-0.48703	9.674488	0.469878	663.5646
-0.043639	323.6945	-0.114391	1.534349	-0.551292	-30.18901	-0.435011	8.070932	0.5219	701.8117
0.008647	384.2432	-0.062568	2.790146	-0.60339	-28.26345	-0.382829	17.45399	0.57423	739.4083
0.060614	450.8455	-0.010292	0.484632	-0.655744	-25.28818	-0.330729	35.97538	0.62581	770.4619
0.112962	501.9468	0.041665	2.178348	-0.707946	-28.45021	-0.278498	66.21754	0.678143	801.3288
0.164939	577.4749	0.093941	7.491334	-0.760346	-28.70137	-0.226447	100.2464	0.73035	840.1876
0.217353	634.5847	0.1461	35.87878	-0.812441	-33.8598	-0.174228	128.3698	0.782471	863.0625
0.269278	691.263	0.1983	22.47073	-0.864895	-34.70343	-0.121988	167.2222	0.834759	896.4602
0.321446	746.2669	0.250421	19.61782	-0.916942	-41.4461	-0.069796	225.8905	0.887002	915.7093
0.373684	808.6059	0.302555	18.74842	-0.969084	-44.87217	-0.01781	278.4858	0.938824	958.825
0.42576	863.378	0.354508	18.49726	-1.021428	-50.26243	0.034295	332.5495	0.991024	993.4593
0.477985	910.918	0.407003	16.03075	-1.073501	-55.57542	0.086398	388.1523	1.043168	999.1973
0.52991	960.8665	0.459115	12.63044	-1.12594	-56.28382	0.138625	442.5508	1.095311	1042.004
0.582214	1016.753	0.511035	13.3646	-1.178134	-57.61045	0.190795	498.9844	1.147179	1068.279
0.63439	1066.611	0.563438	12.70772	-1.230379	-63.61896	0.242612	556.3518	1.199469	1089.731
0.686191	1112.097	0.615492	12.302	-1.282791	-59.37501	0.294845	584.9453	1.25175	1141.914
0.738573	1161.041	0.667399	14.1374	-1.33489	-57.11457	0.347184	632.5046	1.303726	1199.358
0.79068	1205.444	0.71981	16.58459	-1.379317	-57.88737	0.399311	673.0572	1.355876	1239.621
0.842594	1289.074	0.771627	16.46223	-1.346573	-37.94919	0.451352	726.6894	1.384871	1245.076
0.89494	1349.758	0.823901	13.80252	-1.294564	-27.92213	0.503426	765.5933	1.338683	1232.75
0.947059	1430.708	0.876082	11.9156	-1.242273	-17.95948	0.555476	812.6503	1.286066	1210.822
0.999125	1495.643	0.928315	13.78964	-1.189882	-10.57282	0.607869	863.4424	1.23367	1185.995
1.051233	1532.434	0.980224	13.17784	-1.137611	-4.229435	0.660096	871.75	1.181162	1177.978
1.103354	1574.166	1.032417	14.1696	-1.085468	-3.772197	0.712183	909.9391	1.128872	1145.024
1.155441	1633.355	1.084561	12.43724	-1.033226	-1.679202	0.764311	940.2972	1.076694	1124.159
1.207603	1700.653	1.136322	8.76001	-0.981097	0.755111	0.816484	994.348	1.024382	1105.109
1.259489	1757.158	1.188998	10.15749	-0.929008	2.513227	0.868725	1026.722	0.97217	1063.443
1.311607	1791.792	1.240947	11.2716	-0.876902	1.914308	0.920891	1054.485	0.919942	1028.486
1.364193	1871.255	1.292933	11.72884	-0.824656	5.11498	0.972761	1121.312	0.867728	962.8758
1.380472	1914.834	1.34508	12.4952	-0.772562	2.377987	1.025041	1152.147	0.815165	923.1282
1.329711	1871.95	1.386039	7.375414	-0.720303	8.59901	1.076761	1158.658	0.763055	909.9971
1.277652	1819.181	1.349192	8.109572	-0.668378	8.045172	1.129119	1214.686	0.710666	861.2013
1.225241	1788.102	1.296722	4.96686	-0.615904	6.113177	1.181086	1261.524	0.658516	832.5369
1.17317	1755.316	1.244409	5.733218	-0.563865	7.227294	1.23322	1299.777	0.606152	816.0313
1.120615	1694.993	1.192139	5.353259	-0.511665	7.658773	1.285406	1317.371	0.553991	783.7605
1.068338	1659.856	1.13977	6.351457	-0.459487	8.328531	1.337542	1371.28	0.501707	765.0073
1.016206	1605.902	1.08751	5.758978	-0.40731	6.216217	1.384301	1416.908	0.449377	740.0394
0.964026	1562.116	1.035128	7.008335	-0.355243	13.41612	1.356686	1412.29	0.39718	702.0242
0.911345	1523.586	0.98276	3.305345	-0.30319	14.66547	1.304269	1373.612	0.344961	664.1442
0.85938	1462.78	0.930603	4.683501	-0.251126	22.09077	1.251731	1360.435	0.292333	637.2959
0.806956	1417.996	0.878166	0.948311	-0.198572	38.94421	1.199506	1326.851	0.240428	617.0422

0.754684	1363.494	0.826032	-2.175081	-0.146518	45.88007	1.147205	1300.975	0.188058	566.6236
0.702209	1316.714	0.773594	0.330073	-0.094513	58.2062	1.094914	1279.008	0.135703	527.7325
0.649922	1259.386	0.72139	-0.159366	-0.042388	71.35664	1.042776	1245.398	0.083508	503.5182
0.59779	1210.152	0.669261	-0.165806	0.009785	90.31595	0.99045	1211.807	0.031146	469.6245
0.545304	1144.412	0.6167	2.152588	0.061881	101.9723	0.937784	1178.963	-0.021017	431.7639
0.493234	1105.94	0.564684	4.406582	0.113903	133.3415	0.885742	1162.599	-0.073255	392.9887
0.441061	1046.467	0.512517	-1.936801	0.166079	188.9379	0.833459	1096.699	-0.12529	360.2092
0.388533	1007.582	0.459986	2.828786	0.218416	221.1571	0.781101	1027.449	-0.177677	324.2805
0.336461	964.4729	0.407797	-1.827322	0.270556	216.4752	0.728604	970.8935	-0.229937	286.6002
0.284402	911.826	0.355504	0.581232	0.32253	214.6398	0.676405	941.5852	-0.282094	245.3263
0.231987	857.0411	0.303262	1.894988	0.374619	220.951	0.624229	889.2474	-0.334294	204.3616
0.179781	790.9797	0.251057	-2.007641	0.426848	232.9873	0.571985	853.4476	-0.386663	168.6519
0.127175	750.1502	0.198621	-1.209083	0.479004	243.8902	0.519585	810.9115	-0.438724	129.1941
0.075148	693.8326	0.146414	-1.376523	0.531148	248.0247	0.4675	792.2098	-0.49092	87.92028
0.022843	642.9309	0.094255	-2.696719	0.583285	254.3616	0.415272	772.5485	-0.543548	45.71263
-0.029099	591.0955	0.042182	0.819511	0.635403	270.687	0.362964	733.0392	-0.595837	24.96945
-0.081483	533.638	-0.01023	-6.605789	0.687451	286.0979	0.310836	677.7262	-0.647774	6.808695
-0.133809	478.0931	-0.062327	-2.31032	0.73963	289.305	0.258482	645.3395	-0.699886	-0.925724
-0.186063	428.5503	-0.114762	-2.34896	0.791579	295.5969	0.206314	603.7823	-0.752379	-5.182553
-0.238285	368.0853	-0.167228	0.658512	0.843931	295.7901	0.153835	571.7755	-0.80452	-15.40281
-0.290437	317.2288	-0.21922	-3.463077	0.895935	321.3375	0.101579	547.3294	-0.856686	-25.2109
-0.342599	259.4299	-0.271699	-9.83222	0.948143	336.8578	0.049494	508.3675	-0.909204	-44.28613
-0.395095	200.0983	-0.323701	-50.37191	1.00038	349.8086	-0.002897	476.7278	-0.961273	-65.24183
-0.447288	140.5929	-0.376023	-70.70294	1.052335	360.5248	-0.055063	429.175	-1.013739	-87.25369
-0.499483	77.38447	-0.428278	-44.36985	1.104674	377.024	-0.107187	391.6878	-1.065804	-106.1937
-0.55193	27.4102	-0.480456	-27.76757	1.156662	384.5137	-0.15954	350.7811	-1.118109	-122.3516
-0.604125	-7.636186	-0.532874	-22.40307	1.20886	408.7345	-0.211774	315.7604	-1.170486	-129.6545
-0.656255	-14.49477	-0.58488	-20.56123	1.260927	406.6157	-0.263944	277.2171	-1.222399	-142.2189
-0.708468	-22.10683	-0.637377	-21.02491	1.312899	431.0941	-0.316288	247.0007	-1.274768	-135.4183
-0.760857	-24.3093	-0.689525	-21.40487	1.365123	438.352	-0.368731	200.1821	-1.326907	-113.7349
-0.812909	-33.29952	-0.741864	-20.06535	1.37997	441.0374	-0.420747	159.681	-1.376391	-102.188
-0.865171	-52.88351	-0.793928	-13.73485	1.329092	425.4784	-0.472994	111.0269	-1.354298	-68.01746
-0.917603	-70.84462	-0.846261	-11.97029	1.27636	417.5186	-0.525495	78.25387	-1.302199	-43.19133
-0.969795	-83.65374	-0.898572	-9.284822	1.224001	411.1559	-0.577559	39.36925	-1.249967	-23.99374
-1.021943	-106.8377	-0.950669	-11.0043	1.171824	408.9921	-0.629784	13.96996	-1.197869	-15.38349
-1.074305	-119.5373	-1.003166	-9.098062	1.119335	394.6696	-0.682032	1.940068	-1.145287	-4.261635
-1.126377	-127.3683	-1.055306	-9.529541	1.067148	382.1502				
		-1.107717	-3.804396	1.014796	369.2316				
		-1.1597	-7.983945	0.962612	355.0637				
		-1.212024	-6.586469	0.910398	349.3643				
		-1.264229	-7.011508	0.858105	338.8542				

		-1.316535	-6.444789	0.805777	319.193				
		-1.368673	-10.95278	0.753551	312.2056				
		-1.365369	-6.14211	0.701149	307.1824				
				0.649188	296.9299				
				0.596434	278.3506				
				0.544412	261.1365				
				0.491998	244.5149				
				0.439949	239.4144				
				0.387507	222.4129				
				0.335463	219.3861				
				0.282924	203.9752				
				0.230772	192.9757				
				0.178712	177.8482				
				0.126116	165.4963				
				0.073966	152.9963				
				0.021665	152.4875				
				-0.030381	134.6166				
				-0.082639	121.3953				
				-0.134899	119.869				
				-0.187253	87.39864				
				-0.239614	77.22991				
				-0.291628	33.63766				

B.1.4.3-Pac 3 Anodize Type III

Pac 3 Anodize Type III 1		Pac 3 Anodize Type III 2		Pac 3 Anodize Type III 3		Pac 3 Anodize Type III 4		Pac 3 Anodize Type III 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
-0.364065	14.19536	-0.649305	8.109572	-1.101073	-41.6071	1.134058	1335.442	-1.118194	-48.1308
-0.311768	24.83421	-0.701675	-2.26524	-1.153381	-45.46464	1.081641	1278.139	-1.066098	-30.38221
-0.259877	41.5846	-0.753903	-2.36828	-1.205327	-45.78664	1.02931	1243.002	-1.013852	-26.38942
-0.207648	62.71419	-0.806326	-4.197235	-1.257608	-48.96156	0.977089	1227.701	-0.961751	-8.486264
-0.155503	80.13434	-0.858537	-13.61893	-1.310073	-43.42317	0.924759	1177.224	-0.909515	-5.388632
-0.103245	98.25645	-0.910763	-19.06072	-1.362215	-38.90874	0.87241	1153.519	-0.856928	0.671392
-0.051135	115.8054	-0.963016	-33.96928	-1.371102	-32.12744	0.820176	1113.501	-0.804776	1.978708
0.000913	129.6449	-1.015005	-38.44506	-1.319244	-21.88787	0.76791	1074.004	-0.752934	6.744296
0.05307	160.647	-1.067399	-49.07748	-1.26698	-14.22429	0.715534	1042.1	-0.700742	6.525336

0.105301	180.1086	-1.119777	-54.9765	-1.21464	-8.982142	0.663428	982.009	-0.648831	7.652333
0.157211	215.9021	-1.171949	-60.79824	-1.16241	-3.025158	0.610969	952.9453	-0.596444	3.762584
0.209557	263.8606	-1.224276	-63.12308	-1.110428	-4.873433	0.558761	914.5823	-0.544417	5.797618
0.261734	279.6386	-1.27639	-68.57774	-1.058203	-8.943502	0.506493	894.6635	-0.492215	13.08124
0.313705	321.6208	-1.328849	-62.7882	-1.00617	-4.171475	0.454249	846.7435	-0.439681	34.20438
0.365821	354.5807	-1.376876	-62.90412	-0.953809	-1.267043	0.402072	826.7087	-0.387751	48.70722
0.41813	393.0596	-1.35291	-47.8732	-0.90173	3.685304	0.349698	772.9993	-0.335545	71.77524
0.470148	429.761	-1.300883	-32.40436	-0.849706	-1.524642	0.297383	749.4289	-0.283549	93.49087
0.522341	458.6444	-1.248229	-19.53083	-0.797191	-0.597285	0.245079	703.3573	-0.231338	114.5238
0.574494	495.8932	-1.196022	-11.34562	-0.745084	0.413793	0.192844	663.9575	-0.179274	141.1081
0.626417	518.8002	-1.144123	-10.06406	-0.69272	-1.202643	0.140556	621.8722	-0.127228	198.8941
0.678641	562.9785	-1.091566	-2.46488	-0.64074	2.983346	0.088376	572.1169	-0.07496	228.8593
0.730782	600.4206	-1.039498	-4.454835	-0.58869	3.524304	0.036185	543.1949	-0.022877	252.5906
0.782965	626.9726	-0.987764	-0.088526	-0.536569	-2.728919	-0.015946	480.5532	0.029224	274.9309
0.835024	652.1852	-0.935278	-0.294606	-0.484138	0.877471	-0.068157	434.3785	0.08116	299.3514
0.887296	678.6535	-0.882886	-0.069206	-0.432185	6.815135	-0.120425	400.6974	0.133455	326.5925
0.939322	741.1536	-0.830849	3.266705	-0.379797	4.309982	-0.172712	342.0034	0.185654	361.6711
0.991254	765.6319	-0.778835	-3.398677	-0.32764	9.545688	-0.22504	306.3838	0.238106	376.1482
1.043607	790.2778	-0.726401	0.993391	-0.275689	25.88393	-0.277265	258.4253	0.290132	427.3203
1.095675	796.8143	-0.674336	-1.260603	-0.223415	52.58409	-0.32938	227.9577	0.342088	449.6606
1.147761	885.9759	-0.622371	0.297873	-0.171304	75.89039	-0.381665	171.434	0.394027	488.4744
1.199891	907.3438	-0.570145	2.023788	-0.119233	101.1094	-0.433874	143.2011	0.446248	499.3
1.252095	925.5883	-0.517748	-1.273483	-0.067097	133.1483	-0.486401	89.0666	0.498482	549.8345
1.304173	979.0144	-0.465866	2.101068	-0.01488	164.1053	-0.538441	57.80692	0.550771	566.8296
1.356418	997.027	-0.413534	3.575824	0.037278	191.4301	-0.59077	20.1137	0.60276	615.5095
1.384869	1007.653	-0.361397	25.30433	0.089276	231.3258	-0.642779	6.531776	0.654991	643.9806
1.338016	1047.439	-0.309145	79.08462	0.141422	267.3768	-0.695252	-3.913876	0.706911	668.8841
1.285762	1038.546	-0.257126	130.9394	0.193715	302.127	-0.747376	-13.61893	0.759039	692.9116
1.233362	1007.486	-0.205162	187.0574	0.245897	329.8125	-0.799507	-21.14083	0.811082	722.2651
1.180943	957.9234	-0.152766	239.8974	0.298191	366.4946	-0.851847	-36.55171	0.863366	724.313
1.128756	921.3636	-0.100917	297.297	0.350028	394.3089	-0.904217	-55.22766	0.915401	747.22
1.076281	934.4561	-0.04866	355.8944	0.402232	422.2262	-0.956471	-75.97084	0.967593	792.2484
1.02413	886.5491	0.003564	408.8955	0.453861	451.9725	-1.008563	-94.55663	1.019767	813.0689
0.971873	888.4553	0.055449	470.5648	0.506315	479.1686	-1.061028	-115.6025	1.071861	812.8757
0.919671	897.8319	0.107773	528.2026	0.558565	508.1871	-1.11312	-132.501	1.124025	856.7191
0.867227	821.5117	0.1599	583.8441	0.61054	539.6915	-1.165433	-142.4057	1.176021	903.3703
0.814824	775.0923	0.212162	640.3099	0.662602	566.527	-1.217706	-144.4858	1.228278	901.9406
0.762812	736.8194	0.264058	696.6211	0.71465	596.4858	-1.270025	-140.4222	1.280453	908.1359
0.710155	711.6842	0.316124	741.8877	0.766913	629.5486	-1.322004	-135.3475	1.332627	938.4489
0.658115	667.7506	0.368404	803.1899	0.819166	645.0497	-1.373067	-115.7506	1.382292	987.3992
0.605896	661.3235	0.420426	841.0119	0.871149	656.6352	-1.359804	-83.87914	1.361767	969.2642

0.553561	610.8469	0.472915	898.6434	0.923588	675.1952	-1.307638	-51.27995	1.309408	919.3415
0.501413	590.3807	0.524863	936.079	0.975407	698.347	-1.255376	-29.82837	1.257188	961.4912
0.449015	551.0774	0.576997	971.9304	1.027741	716.6108	-1.203047	-11.15242	1.204933	932.3889
0.396645	557.2341	0.629008	1036.369	1.079614	728.1319	-1.150813	-4.963593	1.152422	892.3322
0.344502	507.4723	0.681121	1079.761	1.131705	755.8818	-1.098726	-2.896359	1.100321	905.8561
0.292275	469.5022	0.733337	1145.816	1.18412	785.2996	-1.046562	-3.572557	1.047706	874.326
0.23974	439.479	0.785466	1175.988	1.236097	790.9668	-0.99433	1.20591	0.995664	849.7703
0.187841	409.1209	0.837653	1242.313	1.28843	831.6482	-0.942234	2.004468	0.943409	844.6377
0.135397	391.8875	0.889901	1300.569	1.34028	873.682	-0.889842	6.055217	0.890875	822.8512
0.083298	355.888	0.941942	1355.708	1.385503	914.7948	-0.837819	3.678864	0.83865	763.7901
0.0308	315.3225	0.993878	1424.584	1.354019	884.0826	-0.785521	7.304574	0.786524	760.4349
-0.021028	298.7782	1.04608	1450.878	1.301864	863.3458	-0.733267	7.053415	0.734147	710.9114
-0.073458	276.6633	1.098202	1470.186	1.249244	846.2348	-0.681113	10.13173	0.681962	690.3485
-0.12599	235.6471	1.150403	1526.445	1.197056	834.9584	-0.62904	7.085614	0.629452	674.2292
-0.177851	220.3585	1.202607	1579.91	1.144487	829.0465	-0.577187	8.966089	0.577379	624.899
-0.230133	176.5666	1.254482	1593.421	1.09217	799.9506	-0.52478	6.190457	0.525196	618.942
-0.282541	169.4118	1.306758	1663.875	1.040106	787.3411	-0.47258	9.423328	0.472673	601.2127
-0.33461	132.5751	1.358808	1756.288	0.987945	763.1525	-0.420373	7.182214	0.420542	611.5553
-0.386943	107.5365	1.383524	1795.373	0.935409	730.4374	-0.36831	18.54878	0.368056	588.4809
-0.439198	80.5465	1.334957	1783.42	0.883209	711.871	-0.315893	35.69846	0.316185	561.8966
-0.491398	55.59157	1.282836	1741.805	0.830854	683.8957	-0.264288	61.16215	0.264028	530.8688
-0.543776	33.95322	1.230294	1710.049	0.778556	667.1195	-0.211944	85.18973	0.211489	515.0844
-0.595861	12.15388	1.178101	1684.276	0.726085	667.7893	-0.159676	112.1668	0.159206	468.0016
-0.648126	-1.440923	1.12542	1644.947	0.674001	646.4987	-0.107596	148.5656	0.107073	443.3365
-0.70043	-3.366478	1.073401	1602.83	0.621598	645.0368	-0.055404	194.0383	0.054964	402.5907
-0.752646	-12.46617	1.021223	1554.227	0.569417	612.5922	-0.003137	220.1009	0.002372	372.5289
-0.804975	-16.90976	0.96882	1500.544	0.517312	566.5785	0.048824	289.8459	-0.049774	325.1435
-0.857079	-29.01693	0.916651	1469.026	0.464935	541.2307	0.101154	324.7056	-0.101888	299.6798
-0.909488	-38.14238	0.864402	1442.771	0.412545	506.2745	0.153076	378.1832	-0.154052	275.3367
-0.961717	-53.24414	0.811852	1413.565	0.360469	492.9501	0.205229	419.6631	-0.206425	222.8186
-1.013818	-64.87475	0.75973	1344.426	0.308269	460.7373	0.257431	487.5728	-0.258745	222.5996
-1.066125	-71.64961	0.707125	1263.9	0.255644	437.0446	0.309508	539.7109	-0.31113	166.2949
-1.118467	-84.98038	0.654866	1208.645	0.203725	406.049	0.361716	588.8737	-0.363363	143.3621
-1.170835	-88.11665	0.602992	1158.928	0.15109	380.3857	0.413586	644.9853	-0.415572	126.6439
-1.222942	-91.15632	0.550627	1125.537	0.099263	332.8393	0.465991	696.0608	-0.467509	92.91771
-1.275155	-95.42603	0.498505	1064.299	0.047036	306.1391	0.517997	747.1878	-0.519984	63.78322
-1.327315	-81.30959	0.446032	1000.389	-0.005304	284.3784	0.570049	785.8277	-0.572288	33.5475
-1.376498	-80.40799	0.39391	951.2645	-0.057604	260.3573	0.622467	854.7742	-0.624346	11.54852
-1.354304	-62.6272	0.341389	904.1946	-0.10966	238.223	0.674538	868.3754	-0.67668	0.233473
-1.302135	-46.9072	0.289168	861.7938	-0.161878	216.3335	0.726493	928.3059	-0.728781	-9.175342
-1.249814	-33.9242	0.236844	818.2144	-0.214483	196.4533	0.7785	982.1249	-0.781429	-14.03753

-1.197717	-24.86314	0.184797	765.6062	-0.266735	161.4649	0.830906	1034.025	-0.833528	-22.53831
-1.145439	-14.72661	0.132476	736.7808	-0.318914	136.4842	0.883228	1060.712	-0.88559	-34.90951
-1.093334	-12.29229	0.080406	687.3411	-0.370998	118.3363	0.935025	1135.802	-0.937912	-52.41339
-1.041057	-8.254425	0.027957	629.9672	-0.423437	96.98778	0.98697	1184.952	-0.990074	-72.64137
-0.988791	-1.537523	-0.02421	563.7191	-0.475373	62.08307	1.039306	1205.425	-1.042161	-90.96312
-0.936769	-1.505323	-0.076426	513.5452	-0.528035	41.14024	1.091364	1255.612	-1.094757	-107.9647
-0.884502	-0.874204	-0.128598	461.2912	-0.580102	20.4679	1.143591	1286.182	-1.146901	-135.3539
-0.832393	3.292465	-0.18086	415.1938	-0.632293	3.221625	1.195682	1298.715	-1.199076	-151.2027
-0.780156	4.509621	-0.233329	362.7208	-0.684709	0.349393	1.24787	1372.446	-1.251458	-174.5992
-0.727946	2.152588	-0.285557	310.8532	-0.736711	-7.803626	1.299803	1402.759	-1.303544	-179.4227
-0.675753	2.088188	-0.337725	256.9827	-0.789158	-7.855145	1.351974	1456.043	-1.355712	-187.6144
-0.623658	1.25743	-0.390084	204.5484	-0.841286	-12.16993	1.386007	1504.401	-1.375674	-179.6932
-0.571396	6.963255	-0.442093	155.1279	-0.893681	-20.90899	1.342317	1508.716	-1.325564	-138.2584
-0.519332	2.912505	-0.494607	102.7709	-0.946009	-34.60683	1.289978	1451.194	-1.273504	-102.0592
-0.466979	8.72781	-0.546607	56.08744	-0.997952	-37.96207	1.237678	1415.645	-1.221246	-86.44225
-0.41497	10.74353	-0.598754	17.78243	-1.050165	-49.66995	1.185189	1352.656	-1.168976	-64.14059
-0.362905	14.54955	-0.651079	4.361502	-1.102607	-59.14317	1.133033	1326.851	-1.116903	-43.12693
-0.310691	22.69613	-0.703547	-3.205478	-1.154603	-67.47651	1.080603	1303.551	-1.06441	-26.1125
-0.258562	35.1253	-0.75565	-7.275547	-1.206933	-71.89433	1.028519	1230.161	-1.012293	-21.15371
-0.206455	51.50862	-0.808157	-15.46077	-1.259364	-75.95796	0.976161	1199.043	-0.960254	-8.608623
-0.154313	65.29662	-0.860068	-26.46026	-1.311204	-66.48475	0.923843	1162.593	-0.908167	-2.645199
-0.102055	97.77345	-0.912392	-41.56846	-1.363875	-66.54915				
				-1.369773	-55.03446				
				-1.317711	-41.2207				
				-1.265637	-33.76964				
				-1.213036	-22.74439				
				-1.161301	-18.21064				
				-1.109038	-14.35309				
				-1.056569	-5.639791				
				-1.0045	-6.29023				
				-0.952428	-1.363643				
				-0.899897	-1.260603				
				-0.847783	4.142543				
				-0.795681	7.143574				

B.1.4.4-Pac 3 Natural Oxide

Pac 3 Natural Oxide 1		Pac 3 Natural Oxide 2		Pac 3 Natural Oxide 3		Pac 3 Natural Oxide 4		Pac 3 Natural Oxide 5	
Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps	Volts	nano Amps
1.097401	21862.31	0.677652	18842.41	0.711892	12635.32	-0.769101	113.0491	0.47145	6483.118
1.045036	21205.2	0.729238	19712.27	0.763927	13212.38	-0.716964	145.6418	0.523523	6835.399
0.992615	20525.36	0.781712	20582.58	0.816305	13772.88	-0.664888	174.5638	0.575723	7184.929
0.940534	19884.99	0.83388	21465.21	0.868361	14338.42	-0.612564	201.6182	0.627952	7522.385
0.888452	19206.59	0.886111	22328.11	0.920427	14933.56	-0.56044	228.0543	0.680127	7892.485
0.836178	18529.16	0.938163	23191.37	0.97267	15502.68	-0.508253	267.3704	0.731998	8265.168
0.783441	17818.6	0.990348	24072.74	1.024807	16039.74	-0.456212	360.7437	0.784229	8643.472
0.731501	17131.22	1.042519	24917.58	1.076848	16625.04	-0.403849	811.3107	0.836094	8986.55
0.679059	16422.71	1.094495	25779.69	1.128826	17186.34	-0.352115	1694.188	0.888233	9330.865
0.626737	15755.7	1.14668	26657.39	1.181243	17747.33	-0.299723	2682.59	0.940536	9676.648
0.574497	15072.27	1.198903	27562.92	1.233105	18331.93	-0.247724	3796.921	0.992749	10017.11
0.522374	14428.71	1.251085	28487.83	1.285261	18892.43	-0.195642	5064.691	1.044732	10386.04
0.470044	13750.22	1.302876	29379.67	1.337463	19470.29	-0.143205	6498.065	1.096936	10729.08
0.417792	13093.82	1.3551	30256.25	1.384568	20021.31	-0.091282	8052.403	1.149252	11102.29
0.365793	12402.75	1.384603	30777.28	1.356474	19780.52	-0.039607	9661.288	1.201526	11469.51
0.313483	11703.32	1.338498	30104.19	1.304098	19269.64	0.012776	11242.93	1.253352	11823.58
0.261153	10998.19	1.286114	29319.44	1.251837	18754.96	0.064742	12747.3	1.305371	12198.41
0.208828	10328.86	1.233411	28500.47	1.1997	18240.31	0.117005	14193.52	1.357598	12561.25
0.156639	9791.84	1.181566	27707.23	1.14713	17727.65	0.169246	15598.76	1.383981	12692.94
0.104101	9125.422	1.12912	26892.81	1.094654	17225.03	0.221172	16963.92	1.336384	12389.32
0.05212	8451.844	1.076621	26081.35	1.042609	16703.65	0.273598	18300.3	1.283991	12064.54
-0.000288	7740.868	1.024402	25239.33	0.990282	16147.27	0.325588	19620.4	1.231746	11733.35
-0.052464	7042.547	0.972201	24436.44	0.937863	15619.71	0.377786	20931.88	1.179325	11350.22
-0.104568	6345.811	0.920245	23598.93	0.885627	15086.65	0.429984	22251.23	1.127123	11037.96
-0.156927	5640.039	0.867532	22768.37	0.833372	14546.67	0.481742	23561.05	1.074596	10751.8
-0.208866	4938.853	0.815192	21946.24	0.781247	14032.88	0.53407	24886.78	1.022222	10428.07
-0.261348	4250.18	0.763203	21097.24	0.728735	13507.95	0.586312	26174.07	0.970186	10116.09
-0.313557	3557.411	0.710594	20278.43	0.676589	12963.77	0.638213	27489.5	0.917625	9790.893
-0.365749	2882.513	0.65847	19457.36	0.624284	12417.43	0.690409	28792.64	0.865582	9472.77
-0.418021	2214.204	0.606444	18616.29	0.572007	11869.06	0.742512	30102.31	0.813285	9153.501
-0.470069	1554.936	0.553904	17815.68	0.519641	11326.62	0.794581	31421.55	0.760899	8822.71
-0.522661	955.9785	0.501519	16991.29	0.467247	10780.55	0.846872	32748.34	0.70841	8455.553
-0.574569	469.6954	0.449261	16130.61	0.415022	10242.18	0.898889	34085.21	0.656424	8131.293
-0.626742	228.299	0.397048	15300.59	0.362852	9706.207	0.951186	35446.65	0.603947	7771.51

-0.678955	134.6037	0.344616	14478.51	0.310725	9162.736	1.003331	36788.66	0.551789	7395.839
-0.731418	44.28296	0.292342	13651.2	0.258257	8616.334	1.055174	38135.1	0.499528	7040.042
-0.783643	-114.9134	0.240278	12818.42	0.206077	8067.827	1.107259	39465.19	0.447339	6700.919
-0.835797	-317.8823	0.188161	11979.17	0.153859	7537.442	1.159579	40804.81	0.39515	6351.227
-0.888071	-562.6661	0.135729	11164.72	0.101637	6994.885	1.211809	42123.07	0.342618	5990.137
-0.940245	-871.9075	0.083684	10329.82	0.049402	6456.991	1.263914	43446.65	0.290544	5633.303
-0.992705	-1232.72	0.031694	9516.775	-0.002742	5919.677	1.316013	44796.05	0.238269	5316.778
-1.045091	-1615.654	-0.020874	8726.838	-0.055029	5380.347	1.368091	46119.57	0.186293	4964.459
-1.097086	-1993.984	-0.073028	7897.547	-0.107376	4838.872	1.377451	46464.97	0.133715	4626.784
-1.149399	-2375.662	-0.125235	7065.21	-0.159616	4297.965	1.325405	45295.77	0.081596	4281.053
-1.201467	-2746.779	-0.177805	6260.861	-0.211908	3766.923	1.273074	44117.71	0.029323	3942.31
-1.254223	-3102.195	-0.229902	5455.244	-0.264045	3232.353	1.220535	42914.71	-0.022817	3599.696
-1.306089	-3446.785	-0.282257	4637.313	-0.316756	2710.05	1.168201	41675.36	-0.07533	3253.302
-1.358352	-3777.626	-0.334281	3833.822	-0.368447	2183.588	1.11608	40463.46	-0.127239	2913.947
-1.373624	-3760.477	-0.386564	3038.361	-0.420746	1664.003	1.063857	39256.38	-0.179577	2575.081
-1.323238	-3181.658	-0.438762	2256.572	-0.4729	1169.535	1.011378	38026.66	-0.231628	2232.654
-1.270925	-2648.93	-0.491059	1511.827	-0.524996	711.6778	0.95915	36762.47	-0.284178	1895.482
-1.218514	-2171.109	-0.543408	855.4955	-0.577491	360.8983	0.9067	35527.22	-0.336427	1553.139
-1.166562	-1738.922	-0.595461	427.462	-0.629505	197.8508	0.854631	34316.61	-0.388319	1226.117
-1.114388	-1347.024	-0.647649	252.8676	-0.681902	125.0919	0.802058	33135.35	-0.440741	898.843
-1.062241	-996.9076	-0.699838	153.2153	-0.734032	49.01634	0.749871	31946.82	-0.493165	586.0659
-1.009864	-687.3956	-0.752036	-8.904862	-0.786312	-68.13338	0.697783	30680.27	-0.545266	312.3408
-0.957763	-433.9823	-0.804329	-234.652	-0.838668	-215.3192	0.645444	29409.36	-0.597533	145.2104
-0.905566	-224.9985	-0.856622	-511.3136	-0.890772	-403.5727	0.593435	28149.91	-0.64947	92.90483
-0.853437	-75.28176	-0.909076	-850.1404	-0.943072	-640.2614	0.541039	26893.42	-0.70194	55.16009
-0.801374	18.46507	-0.96094	-1265.21	-0.995142	-914.8687	0.488697	25624.66	-0.754162	0.458873
-0.748926	82.61373	-1.013504	-1720.394	-1.047302	-1202.188	0.436559	24356.99	-0.80641	-66.81319
-0.69702	120.8093	-1.065759	-2196.264	-1.099706	-1494.377	0.384142	23099.21	-0.858986	-155.569
-0.644657	137.6305	-1.117762	-2668.649	-1.15197	-1782.862	0.331885	21856.44	-0.910883	-272.5964
-0.59262	156.9311	-1.169917	-3146.953	-1.204391	-2057.244	0.279787	20591.98	-0.9633	-420.0527
-0.540198	180.8299	-1.222503	-3617.85	-1.256358	-2305.743	0.227314	19320.18	-1.015379	-578.3345
-0.488328	215.0455	-1.274329	-4079.455	-1.308605	-2533.622	0.174829	18043.21	-1.067549	-739.0121
-0.435956	293.6262	-1.3265	-4525.275	-1.361061	-2748.634	0.122948	16772.07	-1.119687	-897.88
-0.38373	580.1089	-1.375997	-4912.009	-1.372624	-2636.623	0.070614	15505.96	-1.172355	-1042.361
-0.331913	1112.927	-1.354628	-4484.748	-1.320655	-2127.143	0.018242	14231.5	-1.224347	-1170.394
-0.279815	1728.113	-1.302295	-3792.721	-1.268531	-1700.295	-0.033922	12978.73	-1.276712	-1293.475
-0.227692	2391.825	-1.250291	-3155.499	-1.216362	-1329.848	-0.08609	11714.32	-1.328651	-1394.589
-0.175525	3138.876	-1.198048	-2582.92	-1.163784	-1022.738	-0.138286	10462.95	-1.377252	-1474.194
-0.123496	3947.037	-1.145848	-2046.985	-1.111986	-752.1174	-0.190673	9218.854	-1.352968	-1266.041
-0.071257	4756.163	-1.093642	-1565.983	-1.059491	-523.614	-0.243027	7978.414	-1.300548	-998.5498
-0.019265	5583.696	-1.041425	-1135.567	-1.007878	-331.3805	-0.294906	6740.544	-1.248808	-782.16

0.032934	6378.719	-0.989333	-753.9786	-0.955414	-178.5082	-0.347366	5515.651	-1.196214	-601.673
0.084954	7162.151	-0.936962	-451.4862	-0.903277	-73.81989	-0.399453	4310.02	-1.144063	-450.8744
0.137203	7920.763	-0.88491	-206.2646	-0.851241	-4.763954	-0.451567	3139.417	-1.091768	-322.0426
0.189095	8650.569	-0.832709	-45.51616	-0.798755	51.49574	-0.503998	2031.205	-1.039815	-218.5778
0.241619	9380.092	-0.780651	74.17092	-0.746582	76.51507	-0.556229	1089.402	-0.98714	-134.5811
0.293529	10128.72	-0.728653	134.945	-0.694691	103.7047	-0.608364	557.1246	-0.935274	-71.90721
0.345671	10864.61	-0.676359	176.6246	-0.642251	120.3907	-0.660535	346.4727	-0.883056	-21.98447
0.397854	11581.72	-0.623972	207.4077	-0.590107	134.8806	-0.712672	207.7941	-0.830829	11.69664
0.45022	12319.46	-0.572065	232.7169	-0.537994	151.9402	-0.764889	-11.1009	-0.778683	30.23735
0.502178	13068.9	-0.519638	260.2413	-0.485514	187.4631	-0.817549	-323.2404	-0.726473	43.65828
0.554186	13789.48	-0.467443	326.4701	-0.433713	271.2666	-0.869656	-706.6512	-0.674251	59.79687
0.606485	14519.64	-0.41542	490.5867	-0.381412	525.7039	-0.921836	-1194.705	-0.622265	64.06014
0.658531	15249.55	-0.363318	987.264	-0.329368	941.3662	-0.973794	-1786.63	-0.570156	73.81672
0.710405	15996.1	-0.311329	1697.266	-0.277106	1426.22	-1.025842	-2429.855	-0.517864	77.50683
0.762854	16727.31	-0.258979	2495.644	-0.22515	1952.83	-1.07835	-3098.788	-0.465696	101.6954
0.814889	17435.5	-0.207201	3353.019	-0.173007	2516.864	-1.130439	-3770.529	-0.413783	181.461
0.867108	18154.67	-0.15469	4270.099	-0.121025	3137.253	-1.182953	-4445.793	-0.361534	383.8955
0.91944	18855.81	-0.102519	5254.316	-0.068838	3780.408	-1.23501	-5107.037	-0.30933	655.5147
0.97154	19562.52	-0.050421	6256.849	-0.01669	4445.292	-1.286965	-5719.356	-0.257304	961.5169
1.023302	20286.93	0.001626	7255.235	0.035563	5099.318	-1.339222	-6306.231	-0.205052	1292.964
1.075475	21037.16	0.053753	8244.798	0.087398	5739.396	-1.379434	-6682.615	-0.15256	1665.497
1.127642	21918.86	0.105599	9202.413	0.13972	6356.521	-1.341713	-5756.495	-0.100697	2088.914
1.179704	22725.25	0.157842	10120.25	0.19176	6957.005	-1.289662	-4719.614	-0.048391	2523.233
1.232025	23488.56	0.20999	11024.44	0.243906	7546.941	-1.237204	-3821.148	0.003458	2963.515
1.283922	24200.17	0.262177	11927.71	0.295881	8130.842	-1.185313	-3026.036	0.05575	3379.384
1.336145	24946.1	0.314265	12815.09	0.348281	8706.011	-1.132972	-2316.344	0.107973	3784.491
1.38373	25654.69	0.366327	13695.89	0.400205	9283.814	-1.080863	-1693.984	0.159932	4175.006
1.357536	25361.89	0.418477	14569.77	0.452208	9861.057	-1.028379	-1164.263	0.212154	4557.554
1.305002	24696.73	0.47068	15443.37	0.504576	10437.67	-0.976364	-716.2983	0.264079	4934.828
1.252769	24087.35	0.52291	16315.05	0.556709	11020.95	-0.924172	-372.3775	0.316187	5306.886
1.200775	23433.64	0.574973	17203.22	0.60878	11634.65	-0.871952	-127.729	0.368404	5680.779
1.148082	22795.78	0.626941	18080.4	0.661057	12234.22	-0.819793	32.24663	0.420475	6048.753
1.095851	22128.46	0.679082	18946.56	0.713218	12816.02	-0.76767	138.4677	0.47247	6404.157
1.043568	21444.75	0.731308	19810.46	0.765259	13394.54	-0.715629	200.9033	0.524804	6764.411
0.991273	20726.48	0.783434	20685.58	0.817568	13963.61	-0.663462	253.7756	0.576921	7119.125
0.938731	20027.59	0.835613	21536.77	0.869664	14525.55	-0.610877	279.1942	0.629027	7483.455
0.886477	19343.04					-0.559163	318.8516		
0.834434	18663.39					-0.506835	377.668		
0.78201	17984.32					-0.454929	495.7387		

B.1.5 Passive Current Density Electrode Areas

		PC1	In mm		PC2	In mm		PC3	In mm		Control	In mm	
	sample #	Height	Width	PC1 area	Height	Width	PC2 area	Height	Width	PC3 area	Height	Width	Control area
Type III	1	5.3	7.32	38.796	4.29	5.98	25.6542	5.44	4.59	24.9696	4.42	3.53	15.6026
	2	3.9	5.11	19.929	2.79	3.57	9.9603	4.59	3.34	15.3306	2.78	4.95	13.761
	3	4.94	2.42	11.9548	1.77	3.21	5.6817	3.81	3.6	13.716	4.43	3.89	17.2327
	4	4.46	6.02	26.8492	2.77	2.58	7.1466	3.8	2.93	11.134	4.68	4.39	20.5452
	5	5.11	6.71	34.2881	4.1	4.1	16.81	4.41	2.55	11.2455	3.65	3.25	11.8625
Type II	1	5.57	5.15	28.6855	5.36	4.36	23.3696	3.49	2.54	8.8646	2.89	4.3	12.427
	2	4.9	5.6	27.44	4.81	3.67	17.6527	4.33	4.79	20.7407	2.47	2.29	5.6563
	3	4.17	5.45	22.7265	3.94	5.6	22.064	6.83	3.34	22.8122	5.9	5.42	31.978
	4	3.3	2	6.6	5.21	5.93	30.8953	3.68	2.91	10.7088	4.07	3.52	14.3264
	5	4.04	4.05	16.362	5.64	2.8	15.792	5.06	2.55	12.903	3.18	2.69	8.5542
Native Oxide	1	6.78	6.96	47.1888	6.64	5.69	37.7816	4.43	3.01	13.3343	4.57	4.2	19.194
	2	4.9	4.9	24.01	6.39	4.49	28.6911	6.9	3.85	26.565	4.04	3.74	15.1096
	3	4.47	7.85	35.0895	3.75	7.59	28.4625	5.93	5.01	29.7093	5.53	6.43	35.5579
	4	4.33	6.35	27.4955	5.98	5.9	35.282	4.57	6.51	29.7507	4.59	5.65	25.9335
	5	6.17	3.8	23.446	7.9	5.36	42.344	3.9	3.6	14.04	4.08	6.92	28.2336
Alodine	1	10.02	3.17	31.7634	2.08	3.43	7.1344	8.24	2.17	17.8808	2.37	2.78	6.5886
	2	2.43	2.71	6.5853	13.4	3.22	43.148	8.6	2.08	17.888	2.78	1.92	5.3376
	3	8.37	3.05	25.5285	7.15	2.28	16.302	2.08	5.92	12.3136	3.2	2.6	8.32
	4	10.48	2.87	30.0776	3.38	1.98	6.6924	2.38	2.14	5.0932	3.04	2.57	7.8128
	5	8.85	2.45	21.6825	5.65	2.45	13.8425	2.01	6.39	12.8439	2.57	2.92	7.5044

Table Values in mm   Failed Seal

<u>B.2 Thermal Conductivity Data</u>

B.2.1 Pac 1

B.2.1.1 Thermal Conductivity Pac 1 Preirradiation

Pac 1 Pre radiation	Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C
Run 1	89	22.5	4.8	Run 4	6	23	23.3	Run 5	7	21.7	22.8
Small end down	143	21.0	4.9	Small end down	7	22	23.3	Small end down	8	21.1	22.8
	176	20.2	4.3		8	19.7	23.3		9	19.8	22.8
	228	19.3	4.3		9	17.6	23.3		10	18.2	23
	277	18.8	4.1		10	16.2	23.3		11	16.9	23
					11	15	23.3		12	15.4	22.9
Run 2	95	20.7	3.9		12	13.7	23.3		13	14.3	22.8
Small end down	140	19.9	4.0		13	13.1	23.3		14	13.1	22.8
	180	19.2	3.7		14	12.7	23.3		15	12.4	22.8
	232	18.6	3.6		15	12.3	23.3		16	11.7	22.8
	282	18.1	3.8		16	11.9	23.3		17	11.2	22.6
					17	11.7	23.3		18	10.7	22.7
Run 3	68	18.2	7.0		18	11.4	23.3		19	10.7	22.8
Large end down	110	16.3	6.7		19	11.1	23.3		20	10.3	22.8
	173	14.5	5.5		20	11	23.3		21	10.1	22.8
	188	14.2	5.5		21	10.9	23.2		22	10	22.8
	240	12.8	4.9		22	10.8	23.1		23	9.9	22.6

288	12.0	5.4

23	10.7
24	10.5
25	10.4
26	10.4
27	10.5
28	10.4
29	10.4
30	10.3
40	9.9
50	9.6
60	9.5
70	9.1
80	9
90	8.8
100	8.6
110	8.5
120	8.5
130	8.4
140	8.3
150	8.3
160	8.6
170	8.5
180	8.5
190	8.2
200	8.3

23
22.9
23
23
22.9
23
23.1
22.9
22.5
22.4
22
21.8
21.6
21.2
21
20.7
20.4
20.2
20.1
20
19.6
19.5
19.3
19.1
19

24	9.9	22.7
25	9.5	22.6
26	9.6	22.6
27	9.5	22.6
28	9.5	22.4
29	9.5	22.5
30	9.3	22.4
31	9.3	22.5
32	9.4	22.5
33	9.2	22.3
40	8.8	22.1
50	8.6	21.7
60	8.6	21.4
70	8.4	21.3
80	8.2	21
90	7.9	20.7
100	7.9	20.4
110	7.6	20.2
120	7.4	20
130	7.1	19.6
140	7	19.3
150	6.7	19.3
160	6.6	19
170	6.6	18.8
180	6.4	18.6

210	8	18.8
220	7.9	18.6
230	7.9	18.6
240	7.5	18.2
250	7.7	18.4
260	7.7	18.2
270	7.9	18
280	7.6	17.8
290	7.6	17.7

190	6.5	18.4
200	6.5	18.4
210	6.3	18.2
220	6.4	18.1
230	6.3	17.8
240	6.3	17.5
250	6.2	17.4
260	6.3	17.3
270	6.3	17.3

B.2.1.2 Thermal Conductivity Pac 1 Postirradiation

Pac 1 Post radiation	Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C
Run 1	100	3.2	18	Run 2	13	17.2	17.9
	110	2.7	17.8	Large end down	14	15.6	18
Small end down	120	2.8	17.5		15	12.4	18.1
	130	3	17.6		16	10	17.9
	140	2.8	17.4		17	8.5	17.9
	150	2.7	17.3		18	7.5	18.2
	160	2.8	17		19	7	18
	170	2.9	17		20	6.8	18.2
	180	2.5	16.9		21	6.5	18.2
	190	2.7	16.9		22	6.2	18.2

200	2.3	16.6
210	2.5	16.3
220	2.7	16.5
230	2.6	16.2
240	2.7	16.1
250	2.7	16
260	2.9	16.1
270	2.7	16
280	3	15.9
290	2.5	15.9

23	5.9	17.9
24	6.1	18.3
25	5.8	18.2
26	5.8	18.3
27	5.8	18.2
28	5.7	18.2
29	5.7	18
30	5.8	18
40	5.3	17.8
50	5	17.3
60	4.7	16.8
70	4.5	16.7
80	4.2	16.2
90	3.2	15.9
100	3.2	15.5
110	3.5	15.2
120	3.4	15.1
130	3.5	14.7
140	3.3	14.3
150	2.9	14.3
160	3.2	14
170	2.7	14
180	2.5	13.7
190	2.1	13.7
200	2.1	13.7
210	1.8	13.5
220	2	13.5

230	1.7	13.3
240	1.8	13.2
250	1.8	13.3
260	1.7	13.2
270	1.7	13.2
280	1.8	13.2
290	1.7	13.2
300	7.9	18.6
310	7.5	18.2
320	7.7	18.4
330	7.7	18.2
340	7.9	18
350	7.6	17.8
360	7.6	17.7

B.2.2 Pac 2

B.2.2.1 Thermal Conductivity Pac 2 Preirradiation

Pac 2 Pre radiation	Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C
Run 1	112	18	8.6	Run 4	13	23.5	23.5	Run 5	5	25	24.8
	135	17.2	8.3	Small end down	14	22.8	23.4	Small end down	6	24.7	24.7
Small end down	152	16.8	8.2		15	16.1	23		7	22.9	24.7

166	16.7	8.1
190	13.1	10.6
202	15.9	10.4
228	15.7	10.1
264	15.3	9.6
294	15	9.3

Run 2

Small end down

67	23.2	7.7
86	22.6	7.7
109	22	7.5
154	21	6.2
196	20.3	5.7
212	19.9	5.4
273	19.1	6.4

Run 3

Small end down

40	21	7.8
81	20.4	7.1
148	19.1	7.3
194	18.4	6.4
219	18.2	7
239	17.8	7
272	17.5	6.6
294	17.2	7.1

16	11	23.2
17	8.1	23.5
18	6.9	23.4
19	6	23.3
20	5.7	23.2
21	5	23.1
22	4.8	23
23	4.5	23.1
24	4.5	23.2
25	4.5	23.1
26	4.3	23
27	4.3	23
28	4.3	23.1
29	4.2	22.8
30	4.1	22.9
40	3.9	22.5
50	4.1	22.1
60	3.8	21.6
70	4.1	21.4
80	3.9	21.2
90	4	21
100	4	20.6
110	3.8	20.5
120	4	20.4
130	4	20.2
140	4.1	20.2
150	3.9	20

8	20.2	24.7
9	18.1	24.5
10	16.4	24.5
11	14.9	24.5
12	13.4	24.4
13	13	24.7
14	12	24.5
15	11.5	24.4
16	11	24.4
17	10.5	24.5
18	10.3	24.2
19	9.9	24.4
20	9.7	24.4
21	9.2	24.2
22	9.1	24.1
23	9.2	24.3
24	8.9	24.4
25	8.6	24
26	8.5	24.2
27	8.5	24.1
28	8.6	24.2
29	8.5	24.2
30	8.3	24
40	8.2	24.3
50	7.9	23.6
60	7.7	23.4
70	7.7	23

160	4.1	19.8
170	3.8	19.6
180	3.8	19.6
190	3.8	19.4
200	4	19.4
210	3.8	19
220	3.8	19
230	3.8	18.9
240	3.7	18.7
250	3.6	18.6
260	3.6	18.4
270	3.6	18.4
280	3.6	18.1
290	3.6	18.2

80	7.7	22.8
90	7.7	22.5
100	7.7	22.3
110	7.6	22
120	7.5	21.6
130	6.7	21.5
140	6.7	21.1
150	6.3	20.9
160	6.2	20.7
170	6	20.5
180	5.8	20.5
190	8.7	20.4
200	5.8	20.3
210	5.6	19.9
220	5.9	20.1
230	6.7	19.8
240	6.6	19.6
250	6.5	19.5
260	6.6	19.3
270	6.6	19.3
280	6.5	19.1

B.2.2.2 Thermal Conductivity Pac 2 Postirradiation

Pac 2 Post radiation	Time (sec)	Thermal couple 1 ˚C	Thermal couple 2 ˚C		Time (sec)	Thermal couple 1 ˚C	Thermal couple 2 ˚C		Time (sec)	Thermal couple 1 ˚C	Thermal couple 2 ˚C
Run 1	11	24.2	23.9	Run 5	12	21.7	20.8	Run 6	16	19.5	19.1
	12	24.4	22.7		13	21.6	18.3	Small	17	19.6	17.4
Large end down	13	24.3	21.3	Small end down	14	21.5	13.9	end down	18	19.6	10.6
	14	24.2	20.1		15	21.4	10.8		19	19.6	6.4
	15	24.2	19.4		16	21.5	8.8		20	19.6	4.8
	16	24.3	19		17	21.6	7.7		21	19.6	4
	17	24.3	18.5		18	21.6	6.8		22	19.7	3.5
	18	24.3	18.2		19	21.5	6.1		23	19.3	2.8
	19	24.2	17.5		20	21.5	5.6		24	19.7	2.5
	20	24.2	17.4		21	21.5	5.4		25	19.5	2.5
	21	24.2	17.1		22	21.5	5.3		26	19.4	2.1
	22	24	16.7		23	21.5	5.1		27	19.6	2.3
	23	24.1	16.5		24	21.4	4.9		28	19.6	2
	24	24	16.3		25	21.7	4.9		29	19.6	1.7
	25	24.2	16.3		26	21.4	4.6		30	19.4	1.7
	26	24.1	15.9		27	21.4	4.6		31	19.5	1.7
	27	24.1	15.7		28	21.5	4.6		32	19.4	1.7
	28	24	15.7		29	21.5	4.5		33	19.5	1.6
	29	24.1	15.5		30	21.4	4.5		34	19.4	1.3
	30	23.9	15.3		40	21.3	4.2		35	19.5	1.4
	31	24	15.2		50	21.2	4.1		40	19.3	1.3
	32	24	15.1		60	20.9	3.9		50	19.3	1.4
	33	23.9	14.8		70	20.5	3.7		60	19.3	1.3

34	23.9	14.7
35	23.8	14.7
36	24	14.6
37	24	14.4
38	23.8	14.4
39	23.7	14.2
40	23.7	14.3
50	23.4	13.7
60	23.1	13.2
70	22.7	12.7
80	22.4	12.6
90	22.1	12.2
100	21.7	11.8
110	21.4	11.6
120	21.2	11.4
130	20.9	11.3
140	20.6	10.8
150	20.3	10.8
160	19.7	10.4
170	19.6	10.2
180	19.5	10.2
190	19.2	9.8
200	18.8	9.8
210	18.6	9.8
220	18.5	9.6
230	18.2	9.4
240	18.1	9.3

80	20.6	3.5
90	20.1	3.4
100	20	3.1
110	19.8	2.7
120	19.4	2.3
130	19.4	2.3
140	19.2	2.4
150	19.1	2.5
160	19	2.4
170	18.7	2.3
180	18.6	2.3
190	18.4	2.1
200	18.4	2.2
210	18.1	2.1
220	18.1	2.3
230	17.9	2.3
240	17.6	2.2
250	17.8	2.1
260	17.7	2.2
270	17.5	2.1
280	17.3	2.1
290	17.3	2.3

70	18.9	1
80	18.9	1.2
90	18.8	1
100	18.8	1.2
110	18.7	1.2
120	18.6	1.3
130	18.6	1.3
140	18.3	1.2
150	18.3	1.1
160	18.2	1.1
170	17.9	1.2
180	17.9	1.1
190	17.9	1.1
200	17.8	1.3
210	17.9	1.5
220	17.6	1.2
230	17.6	1.5
240	17.5	1.3
250	17.6	1.3
260	17.4	1.4
270	17.5	1.3
280	17.3	1.3
290	17.2	1.3

250	17.8	9
260	17.7	9.1
270	17.6	9.1
280	17.4	8.9
290	17.2	8.8

B.2.3 Pac 3

B.2.3.1 Thermal Conductivity Pac 3 Preirradiation

Pac 3 Pre radiation	Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C
Run 1	56	23.5	9.9	Run 5	7	25.6	25.5	Run 6	8	21.8	22.1
Large end down	83	22	9.9	Large end down	8	24.3	25.2	Large end down	9	17.3	22.1
	162	19.1	8		9	21.7	25.5		10	14	22.4
	180	18.7	8		10	20.3	25.2		11	10.9	22.5
	194	18.3	8		11	19.1	25.2		12	9.9	22.4
	215	17.7	7.8		12	17.5	25.3		13	9.2	22.5
	245	17.1	7.5		13	16.7	25.2		14	9	22.5
	272	16.4	7.2		14	16.2	25.3		15	8.9	22.4
	297	16	6.8		15	15.2	25.2		16	8.6	22.4
					16	14.5	25.3		17	8.6	22.3
					17	14.2	25		18	8.6	22.2
Run 2	102	21.1	14.1		18	13.6	25.3		19	8.4	22.1
Small	149	20.3	13.2		19	13	25.4		20	8.2	22.1

end down	197	19.3	12.9
	199	19.2	12.7
	243	18.6	11.8
	273	18.2	11.9
	295	17.7	11.6

Run 3	108	18.9	6.2
Small	160	17.9	5.7
end down	222	17.1	8.8
	252	16.7	8.9
	291	16.3	8.9

Run 4	5	22.1	21.4
Small	6	21.4	21.4
end down	7	20.5	21.5
	8	19.3	21.4
	9	17.6	21.5
	10	16.1	21.5
	11	14.7	21.4
	12	13.5	21.3
	13	12.4	21.3
	14	11.6	21.3
	15	11	21.5
	16	10.3	21.5

20	13.1	25.1
21	13.1	24.8
22	12.5	25
23	12.7	24.9
24	12.3	25
25	12.2	24.9
26	12.4	24.7
27	12.4	24.6
28	12.3	24.6
29	12.4	24.4
30	12.4	24.5
31	12	24.5
32	12.2	24.5
33	12.2	24.5
40	11.6	24.1
50	11.4	23.5
60	11.4	22.9
70	10.3	22.3
80	10.3	21.5
90	10	21.2
100	9.7	20.7
110	10	20.4
120	9.6	20.1
130	9.5	19.7
140	9.3	19.8
150	9.6	18.9

21	8.2	21.9
22	8.3	22
23	8.4	21.6
24	8.2	21.7
25	8.2	21.6
26	8.3	21.6
27	8.3	21.6
28	8.1	21.5
29	8.1	21.3
30	8.1	21.2
31	7.9	21.1
32	8.2	21.3
33	7.8	21
34	8	21
35	7.9	20.8
36	7.8	20.7
37	7.8	20.5
38	7.6	20.6
39	7.8	20.5
40	7.7	20.5
50	7.6	19.8
60	7.3	19.3
70	6.9	18.5
80	6.6	17.9
90	6.6	17.6
100	6.6	17.1

17	9.8	21.3
18	9.2	21.2
19	9.1	21.5
20	8.7	21.4
21	8.4	21.3
22	8.3	21.3
23	8.1	21.3
24	8.1	21.3
25	7.9	21.4
26	7.6	21.1
27	7.5	21.2
28	7.6	21.5
29	7.4	21
30	7.2	21.1
40	7.8	21
50	7.8	21
60	7.7	20.7
70		
80	6.9	20.5
90	7	20.2
100	7.4	20
110	7.4	19.7
120	7.5	19.7
130	7.4	19.5
140	7.1	19.3
150	7.3	19.2
160	7.2	18.9

160	8.9	19
170	9.1	18.6
180	8.9	18.4
190	9.1	18.1
200	8.9	17.8
210	9.1	17.6
220	9.1	17.7
230	9.6	17.2
240	9.7	17.1
250	9.8	16.9
260	10.1	16.6
270	10.2	16.7
280	10.9	16.6
290	10.9	16.5

110	6.9	16.8
120	6.8	16.2
130	6.5	15.9
140	6.2	15.5
150	6.3	15.4
160	6	14.9
170	5.8	14.6
180	5.5	14.5
190	5.4	14.2
200	5.3	14
210	5.4	13.7
220	5.3	13.4
230	5.2	13.2
240	5	13
250	5	12.9
260	4.8	12.8
270	4.8	12.4
280	4.8	12.4
290	4.7	12.3

170	7.1	18.7
180	7.1	18.6
190	6.9	18.5
200	6.5	18.4
210	6.5	18.2
220	7.1	18
230	7.1	17.8
240	7.1	17.8
250	5.8	17.7
260	6.3	17.6
270	6.6	17.3
280	6.6	17.4
290	6.7	17.2

B.2.3.2 Thermal Conductivity Pac 3 Postirradiation

Pac 3 Post radiation	Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C		Time (sec)	Thermal couple 1 °C	Thermal couple 2 °C
Run 1	17	19.4	19.5	Run 5	13	22.8	22.4
Small end	18	19.5	18.3	Large end	14	22.6	17.2
down	19	19.4	12.3	down	15	22.7	11.5
	20	19.6	9.3		16	22.6	8.9
	21	19.5	7.9		17	22.6	7.9
	22	19.6	7.4		18	22.8	7.2
	23	19.4	7.5		19	22.7	6.6
	24	19.5	7.1		20	22.8	6.3

25	19.4	6.9
26	19.6	6.8
27	19.4	6.7
28	19.7	6.7
29	19.6	6.3
30	19.7	6.6
40	19.4	6.5
50	19.4	6.4
60	19.1	6.1
70	19.3	6.2
80	19	6.1
90	18.8	6
100	18.7	6.7
110	18.6	6.7
120	18.4	6.7
130	18.4	6.7
140	18.1	6.7
150	18.2	6.6
160	18	6.6
170	17.9	6.5
180	18	6.5
190	17.9	6.5
200	17.7	6.7
210	17.6	6.6
220	17.7	6.6
230	17.4	6.4
240	17.2	6.1
250	17.4	6.2
260	17.2	6.2
270	17.1	6.1

21	22.5	6
22	22.5	5.6
23	22.4	5.3
24	22.4	5.3
25	22.4	5.1
26	22.3	5.1
27	22.4	4.7
28	22.1	4.6
29	22.2	4.5
30	22.1	4.5
40	21.5	4
50	20.9	3.9
60	20.4	3.7
70	20	3.6
80	19.7	3.6
90	19.2	3.6
100	18.8	3.6
110	18.2	3.5
120	17.8	3.6
130	17.8	3.7
140	17.4	3.5
150	17.1	3.6
160	17.1	3.5
170	16.6	3.4
180	16.7	3.3
190	16.4	3.1
200	16	3.3
210	15.8	3.2
220	15.9	3.4
230	15.5	3.2

280	17.1	6.3
290	17.1	6.4

240	15.3	3.2
250	15.3	3.2
260	15	3.1
270	15.3	3.4
280	15	3.2
290	14.8	3.2

B.3 Weight Gain Measurements

B.3.1 Weight Gain Measurements

table in grams		Pre rad				Post rad 24 hr dry			15-Jul	Post rad 24 hr dry time			22-Jul	Post rad 168 hr dry time			29-Jul
	Sample number	PC1	PC2	PC3	NI	PC1	PC2	PC3	NI	PC1	PC2	PC3	NI	PC1	PC2	PC3	NI
Type III	1	0.5799	0.6832	0.6104	0.3252	0.5882	0.6864	0.6134	0.326	0.5871	0.6865	0.6131	0.3261	0.5834	0.686	0.612	0.3261
	2	1.3395	1.1299	1.1508	0.6337	1.3516	1.1343	1.1572	0.6356	1.3502	1.1343	1.1568	0.6356	1.3455	1.1339	1.1546	0.6355
	3	1.9488	1.6406	3.5695	1.1868	1.966	1.6479	3.5854	1.1949	1.9638	1.6477	3.5849	1.1946	1.9565	1.6466	3.582	1.1918
	4	3.2162	2.228	5.4103	1.8504	3.2876	2.2343	5.438	1.8598	3.285	2.2337	5.4363	1.8592	3.2313	2.232	5.4292	1.857
	5	4.5311	4.0828	7.5538	3.4097	4.5778	4.1066	7.5885	3.4216	4.5711	4.104	7.5863	3.4209	4.5511	4.097	7.5771	3.4184
Type II	1	0.3242	0.2612	0.226	0.3146	0.3256	0.2619	0.2271	0.3167	0.3256	0.262	0.2272	0.3168	0.3252	0.2616	0.2268	0.316
	2	0.6456	0.5824	0.5427	0.5649	0.6479	0.544	0.5457	0.5669	0.6477	0.584	0.5456	0.5669	0.6473	0.5835	0.545	0.5661
	3	0.9359	0.9316	0.8297	0.8926	0.9391	0.9341	0.8337	0.8951	0.9389	0.934	0.8337	0.8951	0.9382	0.9335	0.8328	0.894
	4	1.1966	1.2785	1.1529	1.1301	1.201	1.2817	1.1577	1.1333	1.2007	1.2815	1.1577	1.133	1.1997	1.281	1.1567	1.132
	5	1.6317	1.5666	1.4524	1.4615	1.6382	1.5708	1.4581	1.4661	1.6377	1.5705	1.458	1.4658	1.6361	1.5697	1.4569	1.4643
Native Oxide	1	0.2312	0.2358	0.2043	0.2088	0.2325	0.2364	0.2053	0.2112	0.2323	0.2366	0.2053	0.2116	0.2319	0.2364	0.2048	0.2113
	2	0.4555	0.4826	0.5895	0.4127	0.4572	0.4846	0.5915	0.4181	0.4574	0.4844	0.5914	0.4184	0.4563	0.4837	0.5909	0.418
	3	0.6729	0.7469	0.8955	0.5727	0.6753	0.7498	0.8983	0.5808	0.6752	0.7495	0.8983	0.605	0.6741	0.7485	0.8974	0.5807
	4	0.8389	1.0391	1.1877	0.7356	0.8416	1.0431	1.191	0.746	0.8414	1.0428	1.1907	0.7676	0.8403	1.0414	1.1898	0.7458

	5	1.0397	1.5522	1.8725	0.9086	1.043	1.5579	1.8766	0.9214	1.0127	1.5575	1.8763	0.9328	1.0416	1.5553	1.8752	0.9213
	6				1.0622				1.0768				1.1082				1.0768
Alodine	1	0.2272	0.3207	0.2209	0.1633	0.2284	0.3213	0.2219	0.1635	0.2283	0.3211	0.2219	0.1635	0.2277	0.3209	0.2216	0.1635
	2	0.4503	0.6054	0.4549	0.3691	0.4526	0.6067	0.4567	0.3696	0.4524	0.6064	0.4566	0.3695	0.4512	0.6059	0.4561	0.3693
	3	0.6855	0.8521	0.769	0.614	0.6884	0.8537	0.771	0.6148	0.6882	0.8535	0.7708	0.6146	0.6866	0.8528	0.7702	0.6143
	4	0.9789	1.0495	1.0354	0.8983	0.9833	1.0517	1.038	0.9008	0.9827	1.0514	1.0378	0.9004	0.9808	1.0505	1.037	0.8993
	5	1.6523	1.7974	1.8513	1.1499	1.6577	1.8003	1.8547	1.1527	1.6571	1.8	1.8544	1.1523	1.6548	1.799	1.8533	1.1515
	6		2.2871	2.3063	1.6912		2.2911	2.3103	1.6947		2.2907	2.3099	1.6943		2.2891	2.3088	1.6931

B.3.2 Weight Gain Area Measurements

	Table in mm	PC1			PC1 area	PC2			PC2 area	PC3			PC3 area	NI			NI area
	sample #	Height	# of sides	Length	Area	Height	# sides	Length	Area	Height	# sides	Length	Area	Height	# sides	Length	Area
Type III	1	8.77	2	7.13	125.06	10.84	2	6.63	143.738	9.41	2	6.76	127.223	6.38	2	5.59	71.33
	2	10.95	2	8.09	177.171	8.61	2	5.44	93.6768	8.59	2	7.76	133.317	6.5	2	5.18	67.34
	3	10.28	2	6.02	123.771	7.93	2	6.87	108.958	30.2	2	7.84	473.536	8.77	2	6.73	118
	4	20.31	2	6.58	267.28	9.04	2	8.08	146.086	23.69	2	7.63	361.509	12.46	2	5.21	129.8
	5	23.24	2	5.85	271.908	30.8	2	6.21	382.536	21.01	2	9.97	418.939	21.97	1	6.97	153.1
														24.01	2	6.13	294.4
				Total=	965.19			Total=	874.996			Total=	1514.52			Total=	834
Type II	1	23.16	2	5.73	265.414	22.66	2	4.87	220.708	20.25	2	4.8	194.4	20.89	2	5.88	245.7
	2	22.03	2	5.68	250.261	21.85	2	5.79	253.023	22.68	2	5.51	249.934	17.74	2	5.82	206.5
	3	22.97	2	4.91	225.565	21.7	2	6.3	273.42	17.55	2	6.66	233.766	22.94	2	5.95	273
	4	21.81	2	5.04	219.845	20.46	2	6.62	270.89	20.9	2	6	250.8	21.25	2	4.68	198.9
	5	24.61	2	6.93	341.095	19.45	2	5.93	230.677	16.44	2	7.72	253.834	20.07	2	6.82	273.8
				Total=	1302.18			Total=	1248.72			Total=	1182.73			Total=	1198

Native Oxide	1	5.85	2	16.21	189.657	9.68	2	9.9	191.664	9.32	2	9.18	171.115	8.86	2	9.41	166.7
	2	8.88	2	9.9	175.824	9.92	2	10.41	206.534	13.41	2	11.38	305.212	10.03	2	7.98	160.1
	3	8.82	2	9.96	175.694	17.65	2	6.1	215.33	16.54	2	7.46	246.777	10.03	2	7.21	144.6
	4	8.13	2	8.42	136.909	17.96	2	7.06	253.595	18.4	2	6.88	253.184	9.08	2	7.09	128.8
	5	9.63	2	8.4	161.784	24.71	2	8.06	398.325	25.45	2	10.54	536.486	8.43	2	7.15	120.5
	6													7.39	2	9.26	136.9
	7													7.16	2	8.56	122.6
				Total=	839.869			Total=	1265.45			Total=	1512.77			Total=	980.2
Alodine	1	17.38	2	5.64	196.046	21.07	2	6.08	256.211	15.98	2	5.6	178.976	4.2	2	15.75	132.3
	2	16.28	2	5.57	181.359	24.59	2	4.88	239.998	19.3	2	4.91	189.526	16.97	2	4.79	162.6
	3	17.92	2	5.29	189.594	18.99	2	5.32	202.054	26.11	2	4.94	257.967	21.14	2	4.8	202.9
	4	20.56	2	5.86	240.963	16.96	2	5.16	175.027	21.26	2	5.09	216.427	21.94	2	5.49	240.9
	5	20.3	2	12.94	525.364	22.46	2	12.74	572.281	24.73	2	12.28	607.369	18.33	2	5.25	192.5
	6					14.28	2	13.21	377.278	11.41	2	15.59	355.764	16.21	2	12.79	414.7
				Total=	1333.33			Total=	1822.85			Total=	1806.03			Total=	1346

Table Values: mm

Presoaked panels

B.4 Flux Map Data

	Copper rod position (cm)	30 sec counts						4 min count
Bottom	0->1	47	48	63	61	51	58	479
	1->2	58	83	65	62	59	69	487
	2->3	67	55	64	60	64	65	505
	3->4	57	64	63	73	58	66	490
	4->5	61	82	69	68	67	60	497
	5->6	59	70	70	44	66	63	496
	6->7	57	57	76	56	59	64	506
	7->8	60	66	56	79	68	62	445
	8->9	63	56	75	64	55	61	426
Top	9->10	48	67	45	63	65	65	385
	Total	577	648	646	630	612	633	4716

B.5 Run Data

		20-May	27-May	3-Jun	10-Jun	Total
Facility	Samples	Run 1733	Run 1734	Run 1735	Run 1736	Hours
CI	Pac-1	368439	0	263405	201190	9.25593
CI	Pac-2	368439	0	0	0	4.09377
FNIF	Pac-3	0	106365	0	0	1.18183

B.6 Wire Resistance Data

B.6.1 In Situ Measurements

Temp corrected Resistance Ohms	Resistance Ohms	time min	Temp corrected Resistance Ohms	Resistance Ohms	time min
RUN 1			RUN 2		
8.53	8.53	12	8.58	8.76	103
8.55	8.55	21	8.59	8.79	104
8.57	8.56	32	8.59	8.80	105
8.58	8.57	42	8.59	8.80	106
8.60	8.58	51	8.59	8.81	107
8.62	8.61	61	8.59	8.81	108
8.63	8.65	70	8.61	8.82	118
8.65	8.75	80	8.62	8.83	128
8.67	8.78	91	8.66	8.84	153
8.67	8.80	100	8.68	8.84	163
8.54	8.70	103	8.69	8.86	173
			8.71	8.88	183
			8.72	8.89	193
			8.74	8.9	203
			8.75	8.92	213
			8.77	8.94	223

B.6.2 Postradiation Measurements

Temp C	Resistance ohms	Date
29.5	8.84	24-Jun
24	8.62	15-Jul
25.3	8.69	8-Jul
30	8.82	28-Jun

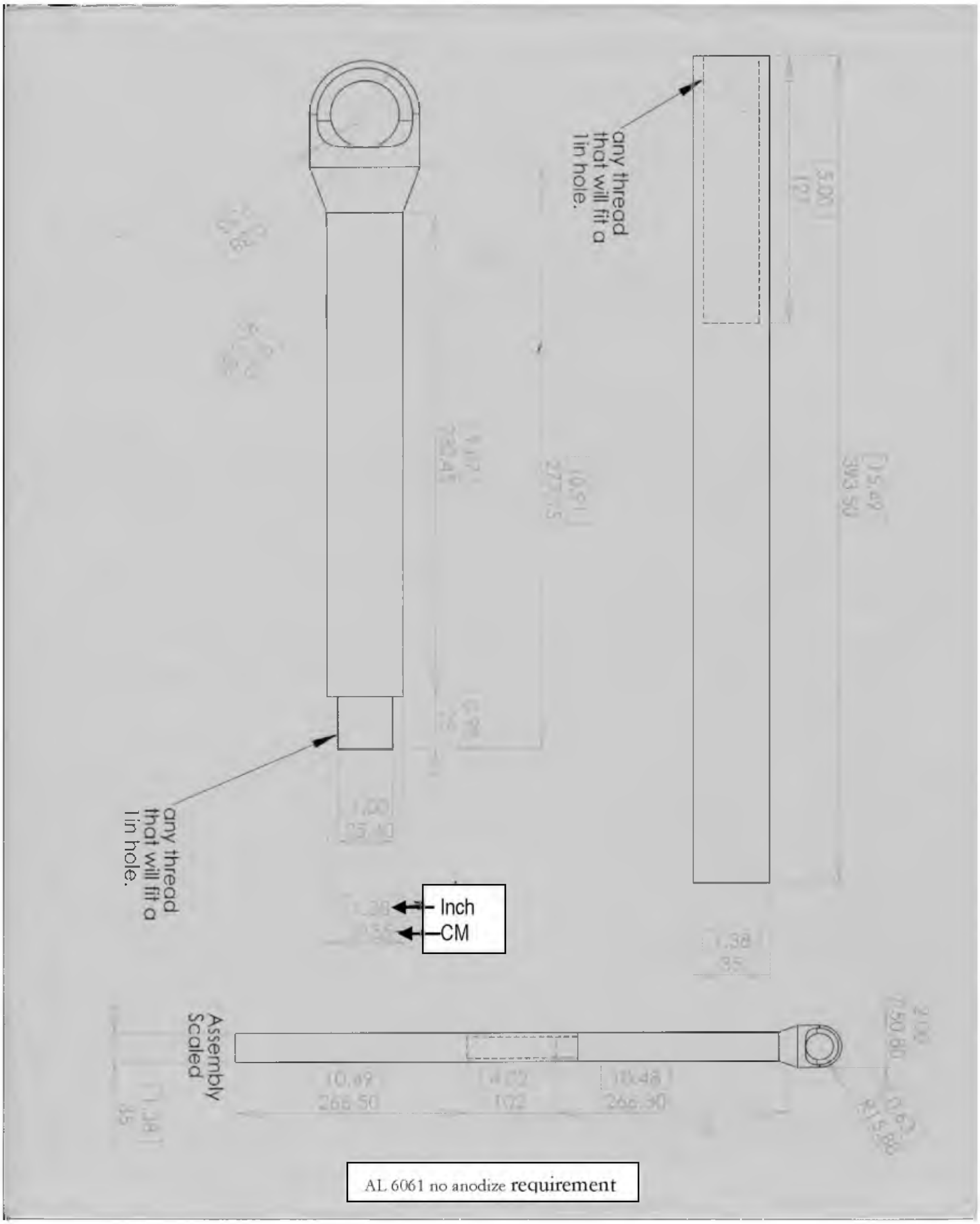
APPENDIX C

CENTER IRRADIATOR DESIGN

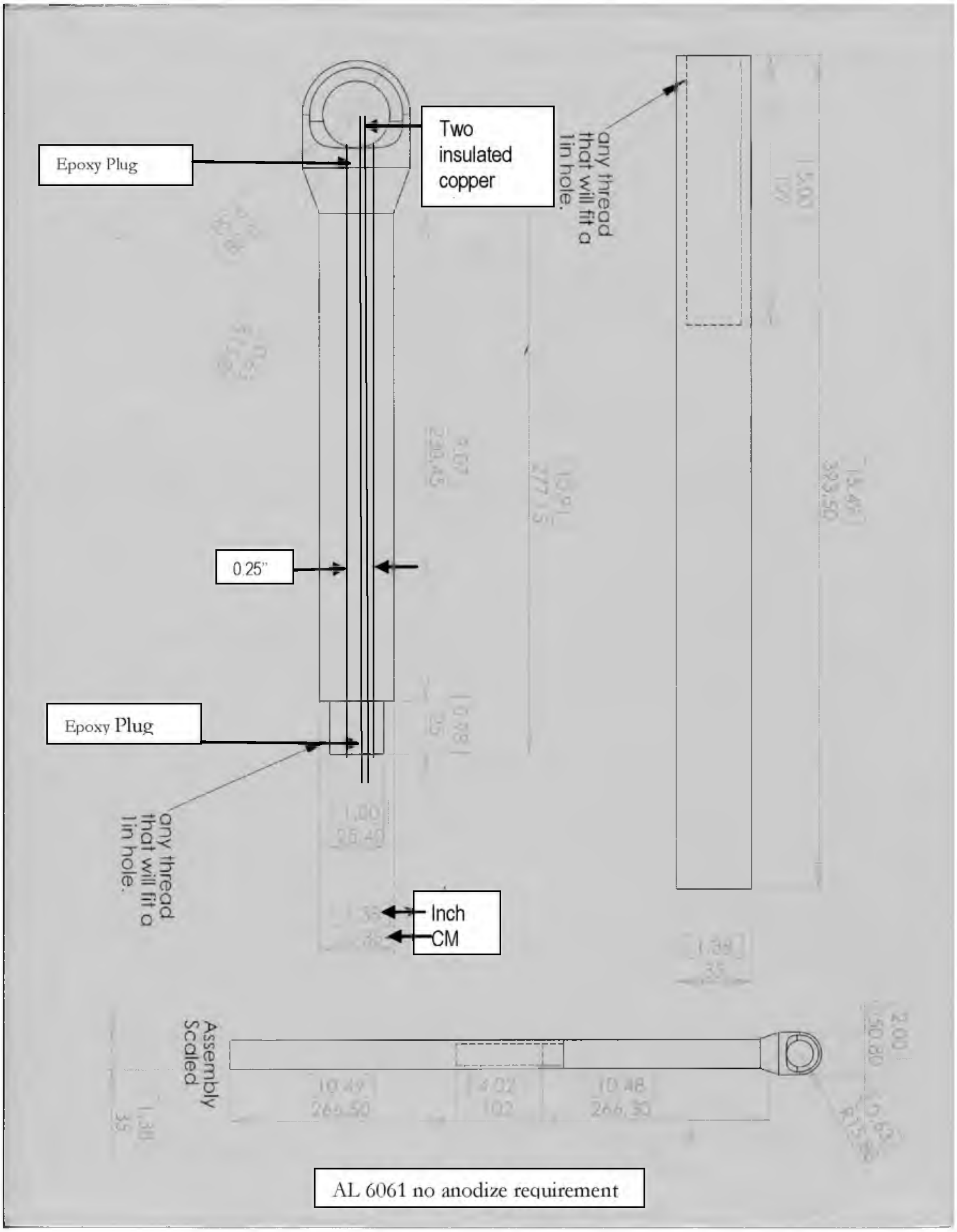
1. Center Irradiator (CI) Drawing
    1.1. CI-Simple Cavity
    1.2. CI-Electrical Measurement Enabled Cavity
    1.3. Cavity Pressure Calculation
2. CI Neutron Energy Spectrum

C.1 Center Irradiator (CI) Drawing

C.1.1 CI-Simple Cavity



C.1.2 CI-Electrical Measurement Enabled Cavity



C.1.3 Cavity Pressure Calculation

$$Pressure\ Rating\ (PR) = \frac{2 * S * t}{D_0}$$

$$S = 7500\frac{lb}{in^2}$$

$$Al\ 6061\ is\ slightly\ stronger, use\ 7500\ for\ conservatism$$

$t = wall\ thickness$=1.38-1=0.38”

$D_0 = Pipe\ outside\ diameter$=1.38”

$PR = \frac{2*7500*0.38}{1.38} = 4130$ Lbs/in2

PV=NRT

V=const

R=const

N=const

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{14psi}{298K} = \frac{28psi}{598\ K}$$

The temperature in the cavity will not reach 300^0 C, however for this calculation 300^0 C was used to provide margin. The ideal gas law demonstrates the pressure would double in the cavity. This doubling of the pressure will not cause the side walls to rupture. The threads are nearly an inch in length and pose no risk of pressure related failure. The gasket used to seal the two pieces of the CI together is the weakest point in the system. As the CI is lowered in the tank the fluid pressure driving water into the cavity is the greatest concern and is easily tested dropping the CI to the bottom of the tank for no lass than an hour without inserting it in the core then removing the device and examining the cavity for moisture. If none is present the gasket is acceptable. As the temperature rises the pressure in the cavity will equalize with the fluid pressure and it is highly unlikely the gasket will need to resist anything greater than 1 atm.

C.2 CI Neutron Energy Spectrum

The spectrum has been generated using MCNP5. The model predicts that 60% of the neutron will be below 100 KeV and 40% will be above. Weaver (1998) reported a total CI Flux of $2.19\text{x}10^{16}$ n/m^2-s and a thermal flux of 1.55 x 10^{16} n/m^2-s; the ratio between the total and the thermal flux is ~1.41 which is close to the modeled value 1.5 for the CI. The difference is likely due to the CI design Weaver was working with and the CI fabricated for this experiment. The average neutron energy is ~575 KeV. Neutron energy data is depicted in Figures 14 and 15.

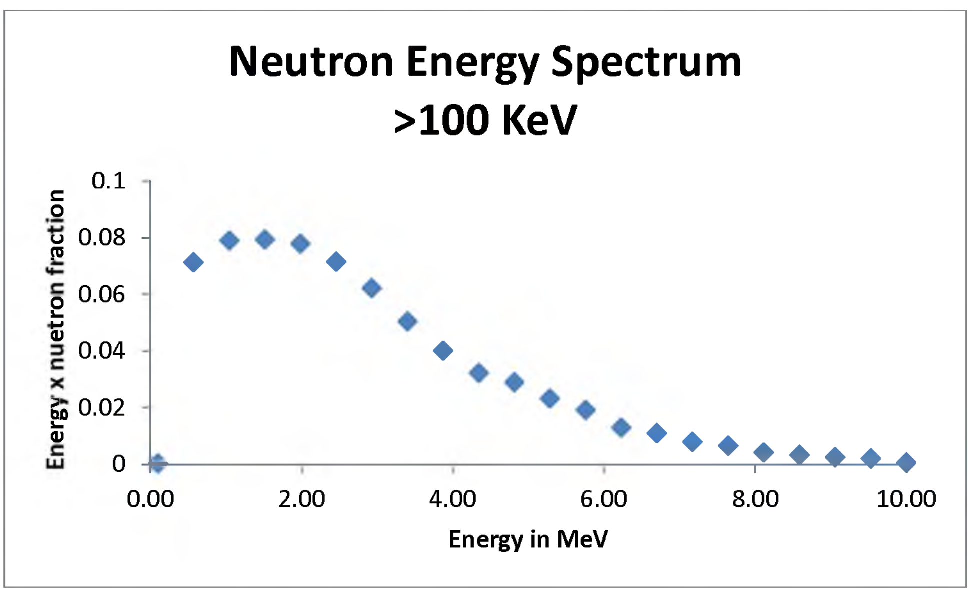


Figure 14
Neutron Energy Spectrum 1

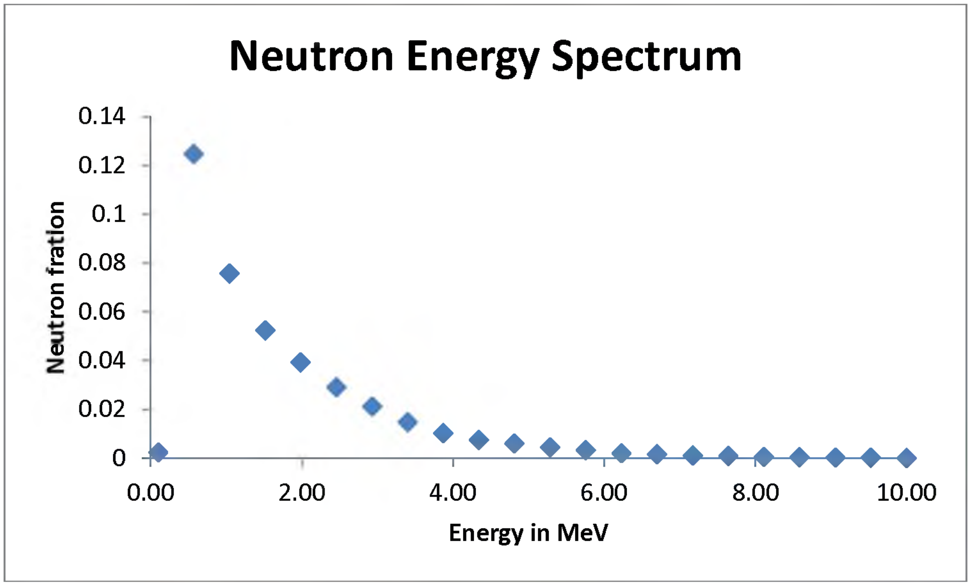


Figure 15
Neuron Energy Spectrum 2

APPENDIX D

EQUATIONS

1. Dissolution Reaction Rate-Passive Current Density

    1.1 Equations

    1.2 Calculation

2. Thermal Conductivity

    2.1 Equations

    2.2 Calculation

3. Weight Gain

    3.1 Equations

    3.2 Calculation

4. Flux Map

    4.1 Equations

    4.2 Calculation

5. Wire Resistance

    5.1 Equations

    5.2 Calculation

6. Displacement Rate

    6.1 Equations

6.2 Calculation

7. Diffusion of Defects Modeled

    7.1 Equations

    7.2 Calculation

8. Concentration of Defects Measured

    8.1 Equations

    8.2 Calculation

9. Point Defect Balance

    9.1 Equations

    9.2 Calculation

10. Property Change

    10.1 Equations Thermal Sample

    10.2 Thermal Defect Calculation

    10.3 Wire Sample Equations

    10.4 Wire Defect Calculation

11. Q-Test Data Rejection

    11.1 Equations

12. Watt-hours to Fluence

    12.1 Equations

13. Uncertainty Analysis

    13.1 Thermal

    13.2 Wire

    13.3 PCD

    13.4 Weight gain

D.1 Dissolution Reaction Rate-Passive Current Density

D.1.1 Equations

Faradays Law

$$Q = nFN$$

$$\frac{dQ}{dt} = \frac{nFdN}{dt}$$

$$\frac{i}{A} = nF\left[\frac{1}{A}\frac{dN}{dt}\right]$$

Dissolution Rate per unit area

$$\frac{i}{nFA} = \left[\frac{1}{A}\frac{dN}{dt}\right]$$

Where

A=Area

n = Number of electrons transferred per molecule

N = number of moles

i = current

t = time

F=Faradays Constant

D.1.2 Calculation

Area Pac 1 mm	Current @ 1.4 V (nA)	i/A
19.19	22979	1197.45
15.11	23909	1582.33
35.56	41809	1175.73
25.93	20388	786.27
28.23	33244	1177.61

i/A Average = 1183 nA/mm^2 Standard Deviation = 282 nA/mm^2

Average [i/A]/[nF] = 1183/[6x96500x100x100] = 2.04 x 10 $^{-10}$ moles/cm^2-sec

Standard deviation = 282/[6x96500x100x100] = $\pm$0.5 x 10 $^{-10}$ moles/cm^2-sec

D.2 Thermal Conductivity

D.2.1 Equations

Unsteady State Heat Conduction

$$\frac{dT}{dt} = \alpha \frac{d^2T}{d^2x}$$

$$\alpha = \frac{k}{\rho c}$$

Where

k = Thermal Conductivity

ϱ = Density

c = Heat Capacity

For solution of heat equation see Transport Phenomena (*46*)

$$T(y,t,N) = T_1 - (T_1 - T_0) * 2 * \sum_{N=0}^{N} \left[\frac{(-1)^N}{\left(N + \frac{1}{2}\right) * \pi} \right] * \cos\left[\left(N + \frac{1}{2}\right) * \frac{\pi * y}{b} \right] * \exp\left[-\left(N + \frac{1}{2}\right)^2 * \pi^2 * \frac{\alpha * t}{b^2} \right]$$

y=0 at the insulated end of the coupon Cos term=1

T_1=Ice Temperature T_0= Initial Temperature

b=1/2 the length of the coupon

y=b at the ice coupon interface

N=summation term

N=0 term is dominate

y=position

t=time

$$ln(T) = \left[\left(\frac{1}{4}\right) * \pi^2 * \frac{\alpha}{b^2}\right] * t + constant$$

$$k = 4 * \frac{\rho c}{\pi^2} * b^2 * slope[ln(T) and\ t]$$

D.2.2 Calculations

Pac 2 Pre-Radiation

Time (sec)	Temp @ insulated end of the coupon	Ln (T)
112	18	2.89
135	17.2	2.84
152	16.8	2.82
166	16.7	2.82
190	13.1	2.57
202	15.9	2.77
228	15.7	2.75
264	15.3	2.73
294	15	2.71

Slope = -0.00092

$$k = 67.6\ \frac{W}{m-k}$$

D.3 Weight Gain

D.3.1 Equations

$$Total\ Weight_2 - Total\ Weight_1 = Total\ Raw\ Weight\ Gain$$

$$\frac{Total\ Raw\ Weight\ Gain}{Total\ Panel\ Area} = Total\ Weight\ Gain$$

D.3.2 Calculation

Raw weight gain data for Type III

Type III	Preradiation				Postradiation 168 hour dry time			29-Jul
Sample number	PC1	PC2	PC3	NI	PC1	PC2	PC3	NI
1	0.5799	0.6832	0.6104	0.3252	0.5834	0.686	0.612	0.3261
2	1.3395	1.1299	1.1508	0.6337	1.3455	1.1339	1.1546	0.6355
3	1.9488	1.6406	3.5695	1.1868	1.9565	1.6466	3.582	1.1918
4	3.2162	2.228	5.4103	1.8504	3.2313	2.232	5.4292	1.857
5	4.5311	4.0828	7.5538	3.4097	4.5511	4.097	7.5771	3.4184

table in grams

Total weight gain (TWG) PC1 = 4.5511g – 4.5311 g = 0.0200 g

Total panel area (TPA) = 965.19 mm^2

TWG/TPA = 0.0200g/965.19mm^2= 2.07 x 10^{-5}g/mm^2

TWG/TPA is used to gain the values reported for the test. Calculating each individual panel weight gain was used to conduct uncertainty analysis.

D.4 Flux Map

D.4.1 Equations

Position count/Total count x 100 = Normalized percent of total

Four minute count and 30 second counts were combined by giving a weighted factor to the normalized percent equal to the total number of minutes counted, adding the results and dividing by the total number of minutes for all the counts.

D.4.2 Calculations

Position 0 -> 1 cm on the copper rod count, four minute count = 479

Total four minute count = 4716

Normalized percent of total =10.16%

Combining 4 minute and 30 second counts 0 -> 1 cm

$$\left[\frac{8.75\% x 3\ count\ minutes\ (30\ second\ counts) + 10.16\%\ x\ 4\ count\ minutes\ (4\ minute\ count)}{7\ total\ counted\ minutes}\right] = 9.5\%$$

D.5 Wire Resistances

D.5.1 Equations

Temperature Resistance Adjustment

$$R_{calc} = R_{ref}\left[1 + \alpha\left(T - T_{ref}\right)\right]$$

$$R_{meassured} - R_{calc} = R_{defect}$$

$$R_{calc} = Temperature\ adjusted\ Resistance$$

$$T = Temperature\ (°C)$$

$$R_{ref} = Reference\ Resistance\ @\ T_{ref}$$

$$T_{ref} = Reference\ Temperature\ (°C) with\ a\ know\ R\ (\Omega)$$

$$\alpha = Temperature\ coefficient\ of\ resistance\ for\ metal = 0.004308\ for\ Aluminum$$

$$R_{wire} = \frac{\rho L}{A}$$

$$\rho = resistivity \sim 10^{-6}\ \Omega - cm$$

$$L = length$$

$$A = area$$

D.5.2 Calculations

$$R_{defect} = 8.80 - 8.4x[1 + 0.004308x(30.4 - 23.0)] = 0.13\Omega$$

$$R_{wire} = \frac{2.7x10^{-6}\Omega cm\ x\ 30cm}{4.9x10^{-6}cm^2} = 16.53\Omega$$

D.6 Displacement Rate

D.6.1 Equations

$$\frac{\#\ primary\ displacements}{cm^3 - sec} = N\int_{\check{E}}^{\hat{E}} \Phi(E_i)\sigma_D(E_i)dE_i$$

$$\frac{displacements}{primary\ displacement} = \sigma_D = \int_{\check{T}}^{\hat{T}} \sigma(E_i)\upsilon(T)dT$$

$$Displacement\ rate\ (DR) = N\int_{\check{E}}^{\hat{E}}\int_{\check{T}}^{\hat{T}} \Phi(E_i)\sigma_D(E_i,T)\,\upsilon(T)dTdE_i$$

Displacement Rate Simplified --- $DR = N\sigma_s\left(\frac{\gamma E_i}{4E_d}\right)\Phi$

$$\gamma = \frac{4m_1m_2}{(m_1 + m_2)^2}$$

$$Defect\ Rate\ (DFR) = 2DR$$

For every dislocation there is an interstitial and vacancy created

D.6.2 Calculation

$$N = 0.6x10^{23}atoms/cm^3$$

$$\sigma_s = 3x10^{-24}cm^{-2}$$

Center Irradiator

$$\Phi_{total} = 2.19x10^{12}neutrons/cm^2sec$$

$$\Phi_{thermal} = 1.55x10^{12}neutrons/cm^2sec$$

$$\Phi_{fast} = 0.64x10^{12}neutrons/cm^2sec$$

Weaver 1998 (36)

$$E_i = 0.580\ MeV$$

$$DR_{CI}^{AL} = 3.67x10^{14} atoms/cm^3 sec$$

Fast Neutron Irradiation Facility

$$\Phi = 2.1x10^{11} neutrons/cm^2 sec$$

$$E_i = 2\ MeV$$

$$DR_{CI}^{AL} = 1.04x10^{14} atoms/cm^3 sec$$

D.7 Diffusion of Defects Modeled

D.7.1 Equations

From Fundamental Principles (*37*)

Diffusion

$$\frac{dC}{dt} = -\frac{d}{dr}\left(D\frac{dC}{dr}\right)$$

Assume D=constant (not a function of C)

T ~ constant

$$\frac{dC}{dt} = -\left(D\frac{d^2C}{dr^2}\right)$$

$$D_a = f_v D_v C_v + f_i D_i C_i$$

$$D_v = \alpha a^2 v * exp\left(\frac{S_m^v}{k}\right) exp\left(\frac{-E_m^v}{kT}\right)$$

$$D_a^v = \alpha a^2 v * exp\left(\frac{S_f^v + S_v^m}{k}\right) exp\left(\frac{-E_f^v - E_m^v}{kT}\right)$$

$$D_i = \alpha a^2 v * exp\left(\frac{S_m^i}{k}\right) exp\left(\frac{-E_m^i}{kT}\right)$$

$$D_a^i = \alpha a^2 v * exp\left(\frac{S_f^i + S_m^i}{k}\right) exp\left(\frac{-E_f^i - E_m^i}{kT}\right)$$

$$E_m^i \sim 0.12\ eV$$

$$-E_m^v \sim 0.62\ eV$$

Neglect

$$S_m^v, S_v^m, S_m^i$$

Nonirradiated equilibrium concentrations at 293 K

$$C_v = exp\left(\frac{S_f^v}{k}\right)exp\left(\frac{-E_f^v}{kT}\right) \sim 1.6 \; x \; 10^{-11}$$

$$C_i = exp\left(\frac{S_f^i}{k}\right)exp\left(\frac{-E_f^i}{kT}\right) = 5.0 \; x \; 10^{-51}$$

$$--E_f^v \sim 0.66 \; eV$$

$$-E_f^i \sim 3.2 \; eV$$

$$S_f^v \sim 0.7 \; k$$

$$S_f^i \sim 8 \; k$$

D.7.2 Calculation

$$D_v = \alpha a^2 \nu * exp\left(\frac{S_m^v}{k}\right)exp\left(\frac{-E_m^v}{kT}\right)$$

$$D_i = \alpha a^2 \nu * exp\left(\frac{S_m^i}{k}\right)exp\left(\frac{-E_m^i}{kT}\right)$$

$$\alpha_{vacancy} = 1$$

$$\alpha_{interstitial} = 1/2$$

a=3.61 Å

ν=1.56e13 sec^{-1}

$$S_m^v = 0$$

E_m^v=0.62 eV

$$k = 1.638x10^{-23} Joules$$

T=Temp in K

$$-E_m^i = 0.12 \; eV$$

$$S_m^i = 0$$

$D_v = 8.37x10^{-17} m^2/s$@298k

$D_i = 1.20x10^{-8} m^2/s$@298k

D.8 Concentration of Defects

D.8.1 Equations

$$C_v^o = N_o ln\left(\frac{-E_f^v}{kT}\right)$$

C_v^o = Equilibrium Concentration of Vacancies

$$C_v^{ss} = \sqrt{\frac{K_o K_{is}}{K_{iv} K_{vs}}}$$

C_v^{ss} = Concentration of Vacancies

$$void\ nucleation = J_n = \rho^0(n)\beta_v(n)Z$$

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) = \text{void concentration of size n}$$

$$\beta_v(n) = \frac{4\pi R_v D_v C_v}{1+\frac{a}{R_v}} = \text{absorption rate}$$

$$R_v = vacancy\ radius$$

$$Z = \left[-\frac{1}{2\pi kT}\frac{d^2(\Delta G_n^o)}{d(n)^2}\right]_{n_k}^{\frac{1}{2}} \sim 0.05 = \text{Zeldovich factor}$$

$$Sv = \frac{C_v}{C_v^o}$$

C_v^o is the equilibrium concentration of defects and C_v is the defect concentration in the sample.

$$\Delta G_n^o = n_k kTlnSv + (36\pi\Omega\text{^}2)^{1/3}\gamma n_k^{2/3}$$

$$\rho^0(n) = N_o exp\left(\frac{-\Delta G_n^o}{fkT}\right) + N_o exp\left(\frac{-\Delta G_n^o}{kT}\right)$$

D.8.2 Calculations

$$-\Delta G_n^o = n_k kTlnSv + (36\pi\Omega\text{^}2)^{1/3}\gamma n_k^{2/3}$$

$$assume\ N_o exp\left(\frac{-\Delta G_n^o}{kT}\right) \sim 0 \ll N_o exp\left(\frac{-\Delta G_n^o}{fkT}\right)$$

$$N_o = number\ of\ defect\ atoms$$

$$T = temp\ K = 298$$

$$k = 1.38x10^{-19} Joules$$

$$f = alloy\ factor = 12.7$$

$$\pi = 3.14159$$

$$\Omega = atomic\ volume = 1.66x10^{-29} m^3$$

$$C_v^{ss} = 6.08x10^{22} for\ the\ CI$$

$$C_v^o = 4.13x10^{17}$$

$$Sv = 5.99x10^4$$

$$n_k = viod\ size = 34\ to\ 48$$

$$\gamma = surfeace\ energy = 0.75\ J/m^2$$

$$Void\ Conc = 1.29x10^{17} viods/m^2$$

D.9 Point Defect Balance

D.9.1 Equations

$$\frac{dC_v}{dt} = K_o - K_{iv}C_iC_v - K_{vs}C_vC_s + \nabla \cdot D_v \nabla C_v$$

$$\frac{dC_i}{dt} = K_o - K_{iv}C_iC_v - K_{is}C_iC_s + \nabla \cdot D_i \nabla C_i$$

$$K_{iv} = 4\pi r_{iv}(D_i + D_v)$$

$$K_{is} = 4\pi r_{is}(D_i)$$

$$K_{vs} = 4\pi r_{vs}(D_v)$$

$$r_{iv} = r_{is} = r_{vs} = 10a$$

For values of D see section 7

Steady state pure metal low temp high sink density

$$C_v^{ss} = \frac{K_{is}C_s}{2K_{iv}} + \left[\frac{K_0K_{is}}{K_{iv}K_{vs}} + \frac{K_{is}^2C_s^2}{4K_{iv}^2}\right]^{1/2}$$

$$C_i^{ss} = \frac{K_{vs}C_s}{2K_{iv}} + \left[\frac{K_0 K_{vs}}{K_{iv}K_{is}} + \frac{K_{is}^2 C_s^2}{4K_{iv}^2}\right]^{1/2}$$

D.9.2 Calculation

$$K_{iv} = 1.22x10^{-17}$$

$$K_{is} = 6.09x10^{-17}$$

$$K_{vs} = 4.26x10^{-25}$$

$$C_s = 6.10x10^{17}\ sites/m^2$$

$$C_v^{ss} = \left[\frac{K_0 K_{vs}}{K_{iv}K_{vs}}\right]^{1/2} for\ low\ sink\ density$$

Low sink density applies- C_v^{ss} for low sink density was $6.08197x10^{22} vacancies/m^2$and for high sink density was $6.08212x10^{22} vacancies/m^2$ which made no difference in the Sv ratio.

$$C_v^{ss} = \left[\frac{K_0 K_{vs}}{K_{iv}K_{vs}}\right]^{1/2} = 6.08x10^{22} vacancies/m^2 \text{ For CI}$$

D.10 Property Change

D.10.1 Equations Thermal Sample

$$\%\ change = \left(\frac{\left(\frac{preread\ value - high\ post\ rad}{preread\ value}\right) + \left(\frac{preread\ value - low\ post\ rad}{preread\ value}\right)}{2}\right) x100$$

$$defects = \frac{fraction\ reduction\ thermal\ conductivity\ x\ \rho}{Specific\ Dislocation\ Resistivity}$$

$$\rho = electrical\ resistivity\ of\ Al\ 2024$$

D.10.2 Thermal Defect Calculation

For Pac 1 thermal conductivity pre-radiation data consisted of five samples taken (four low and one high). Post-radiation data consisted of one low and one high sample.

$$\%change = \left(\frac{\left(\frac{148-110}{148}\right)+\left(\frac{76-53}{76}\right)}{2}\right)x100 = 28\%$$

$$defects = \frac{0.282 * 5.82x10^{-8} \cap -m}{1.1x10^{-25} \cap -m^3} = 1.49x10^{17} defects/m^2$$

D.10.3 Wire Sample Equations

$$\Delta R = R - Rcal$$

where R=resistance of the wire (measured) and Rcalc=temp adjusted resistance (section D.5.1)

$$\Delta\rho = \Delta R\frac{A}{l}$$

$\boldsymbol{\Delta\rho} =$ Change in resistivity resulting from irradiation

A=area

L=length

$$Defects = \Delta\rho/SDR$$

D.10.4 Wire Defect Calculation

At time=100 minutes on the first wire sample run

$$\Delta R = 8.80 - 8.66 = 0.13\ ohm$$

$$\Delta\rho = 0.13ohm\ x\frac{5.1x10^{-6}cm^2}{15.84cm} = 4.25x10^{-8}ohm - cm \rightarrow 4.25x10^{-10}ohm - m$$

$$defects = \frac{4.25x10^{-10}ohm - m}{1.1x10^{-25}ohm - m^3} = 3.87x10^{15}defects/m^2$$

D.11 Q-Test Data Rejection

D.11.1 Equations

$$Q_n = \frac{|X_a - X_b|}{R}$$

$$R = Range$$

$$X_a = outlier$$

$$X_b = cloest\ value\ to\ X_a$$

N	3	4	5	6	7	8	9	10
Qn	0.94	0.76	0.64	0.56	0.51	0.47	0.44	0.41

D.12 Watt Hours to Fluence

D.12.1 Equations

$$\frac{Total\ power\ (kW)}{90\ kW} = hours\ at\ 90\ Kw$$

$$Flux = \frac{neutrons}{cm^2 sec} @90kW$$

$$hours\ @\ 90\ kW\ x\ flux\ x\ 3600 = fluence\ \left(\frac{neutrons}{cm^2}\right)$$

D.13 Thermal Uncertainty

D.13.1 Equation

For Pac II five data, five preradiation samples were taken

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}}$$

$$\text{stdev} = \sqrt{\sum \frac{(67.5-67.9)^2+(69.8-67.9)^2+(58.8-67.9)^2+(72.7-67.9)^2+(70.8-67.9)^2}{5-1}} = 5.45$$

Preradiation Pac II thermal conductivity y value=67.9±5.5 W/m-K

D.13.2 Wire

The given the temperature correction which eliminated the temperature effects and the immediate vacancies created by the radiation process the loss of vacancies to sinks (solute atoms) was not expected to occur until about 1 hour after the start of the bombardment. The data indicated no real changes for about the first hour support the assumption so the first 60 minutes of data was used to determine the uncertainty of the measurements and then assigned to the remaining measurements.

time (min)	R (ohm)
12	-0.00027392
21	0.000578929
32	-0.006827573
42	-0.012493424
51	-0.019899925
61	-0.005565776

The data was plugged into the stdev equation below resulting in an uncertainty of 0.007 Ohms

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}}$$

The uncertainty value was later propagated through the recovery equation using

$$\frac{\delta q}{|q|} = \frac{\delta x}{|x|} + \frac{\delta y}{|y|}.$$

with $q_{best}=x_{best}/y_{best}$

And the normalization

Recovery=1-value$_{@time}$/value$_{initial}$

Normalized Recovery=1-2.179$\pm$.007/2.371$\pm$0.007=.19

$$\frac{\delta q}{|q|} = \frac{0.007\ ohm}{2.179} + \frac{0.007\ ohm}{2.371} = 0.006\ ohm$$

The SDTEV equation below was used to calculate the uncertainty for the f factor used to describe the alloying in a radiation environment; however there were only two values determined using the method equations in section D.8.

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}}$$

D.13.3 PCD

The uncertainly of the PCD results by taking the amperage values at 1.5 volts for each sample tested in each category, averaging the values and then determining the standard deviation using the equation below. The uncertainty was then propagated through the calculations at the high and low extremes to determine the high and low dissolution rates.

$$stdev = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n-1}}$$

D.13.4 Weight Gain

Total weight gain divided by the total surface area was used to determine the weight gain per unit area; the uncertainty was calculated by averaging the individual samples and then taking the standard deviation of those values.

$$Average = \frac{\sum weight\ gain}{\sum surface\ area}$$

$$uncertainty = \sqrt{\frac{\sum_n^i (x_i - x_{mean})^2}{n}}$$

For Type III Pac I

$$Average = \frac{0.0200g}{965.19mm^2} = 2.07x10^{-5}g/mm^2$$

g/mm^2

PC1
2.80E-05
1.41E-05
1.37E-05
2.77E-05
1.80E-05

Applying the uncertainty equation yields the result 6.33 x 10^{-6}g/mm^2.

D.13.5 Diffusion

The uncertainty of the Diffusion was calculated using the equations below.

$$\delta t = \frac{\delta x}{\rho}$$

$$\delta D = \frac{\delta t \cdot J}{dC}$$

where δx is uncertainty of the weight gain in mass/area, ρ is density, and δt is the uncertainty in thickness. δD is the uncertainty of the diffusion coefficient, J is the flux, and $dC$is the concentration of the oxygen in the water. δx is demonstrated in section 13.5. Using the data from section 13.5,

$$\delta t = \frac{6.33x10^{-6}g/mm^2}{0.0037g/mm^3} = 0.00171 \text{ mm}$$

And propagating the uncertainty into the diffusion

$$\delta D = \frac{0.00171\ mm\ x \frac{1.53x10^{-11}moles}{mm^2 - sec}}{3.6x10^{-5}moles\ O/mm^3} = 7.3x10^{-10}\text{mm}^2/\text{sec}$$

The flux uncertainty described in section D.14.1 was not incorporated into the uncertainty calculations for the diffusion coefficient because the source of uncertainty was primarily the mass measurements. The method described here accounts for that uncertainty in δt. Including the uncertainty in J would double count the uncertainty in the calculation.

D.14 Diffusion

D.14.1 Diffusion of Oxygen Through Al 2O3

$$Flux = \frac{\frac{(m_{post-rad} - m_{pre-rad})}{area} - \frac{(m_{control-final} - m_{control-initial})}{area}}{irradiation\ time\ (sec)\text{x}\ 16\frac{\text{g}}{\text{mol}}\ \text{O}}$$

where $m_{control\ (initial-final)} =$ weight gain of non-irradiated samples over the same time in de-ionized aqueous storage and $m_{post-pre\ rad}$ is the weight gain of the irradiated samples. This was how the control (nonirradiated) samples were incorporated into the results.

The uncertainty for flux was propagated using $\delta f = \sqrt{\delta x^2 + \delta y^2}$ with $\delta x, \delta y, \delta i$ ... representing each of the uncertainties for the mass values in the flux equation. The area uncertainty was so small compared to the mass uncertainties that they were ignored. The final δf value was then divided by $irradiation\ time\ (sec)\text{x}\ 16\frac{\text{g}}{\text{mol}}\ \text{O}$ to obtain the uncertainty for Flux which was included in the tabulated data and the graphics contained in the main body of the report.

The ending thickness can be calculated as such:

$$\frac{wt\ gained}{alumina\ density} = volume\ gained$$

$$\frac{volume\ gained}{area} = thicknes\ gained$$

Fick's Law

$$J = -D(x)\frac{dC}{dx}$$

D.14.2 Calculation of Diffusion of Oxygen Through Al 2O3

Data for Pac I Type III

$$volume\ gained = \frac{0.0113g}{3.7\frac{g}{cm^3}} = 0.0031cm^3$$

$$thickness\ gained = \frac{0.0031cm^3}{9.65cm^2} = 3.2x10^{-4}cm$$

$$D(x) = \frac{\left(\frac{4.5511g - 4.5311g}{9.6519cm^2}\right) - \left(\frac{3.4184g - 3.4097}{6.8091cm^2}\right)}{9hrs\ x\ 3600\ sec/hr\ x\ 16\frac{\mathrm{g}}{\mathrm{mol}}\ \mathrm{O}}\, x\, \frac{3.2x10^{-4}cm}{3.6x10^{-2}mol\frac{O}{cm^3}} = 1.3x10^{-11}cm^2/sec$$

APPENDIX E

FIGURES AND DATA RESULTS

1. Passive Current Density Figures

    1.1. Alodine

        1.1.1. Alodine Control Set

        1.1.2. Alodine PC1

        1.1.3. Alodine PC2

        1.1.4. Alodine PC3

    1.2. Natural Oxide

        1.2.1. Natural Oxide Control

        1.2.2. Natural Oxide Pac 1

        1.2.3. Natural Oxide Pac 2

        1.2.4. Natural Oxide Pac 3

    1.3. Type II Anodize

        1.3.1. Type II Control

        1.3.2. Type II Pac 1

        1.3.3. Type II Pac 2

        1.3.4. Type II Pac 3

    1.4. Type III Anodize

1.4.1. Type III Control

1.4.2. Type III Pac 1

1.4.3. Type III Pac 2

1.4.4. Type III Pac 3

1.5. Dissolution Rates For Passive Current Density

1.5.1. Tabulated Dissolution Data

1.5.2. Type II/Type III PCD Results

1.5.3. PCD NO/Alodine Results

2. Weight Gain Figures

2.1. Native Oxide Weight Gain

2.2. Alodine Weight Gain

2.3. Type II Weight Gain

2.4. Type III Weight Gain

2.5. Radiation Enhanced Flux

2.6. Type III Diffusion Coefficient

2.7. Type II Diffusion Coefficient

2.8. Alodine Diffusion Coefficient

3. Thermal Conductivity Data Results

4. Wire Resistance Figures

4.1. Increased Resistance

4.2. Void Recovery

4.3. Total Defect Comparison

4.4. Defect Concentration

4.5. Defect Recovery

5. Flux Map
6. Neutron Cross Section

E.1 Passive Current Density Figures

E.1.1 Alodine

Data for the Alodine test sets are depicted in Figures 16-19.

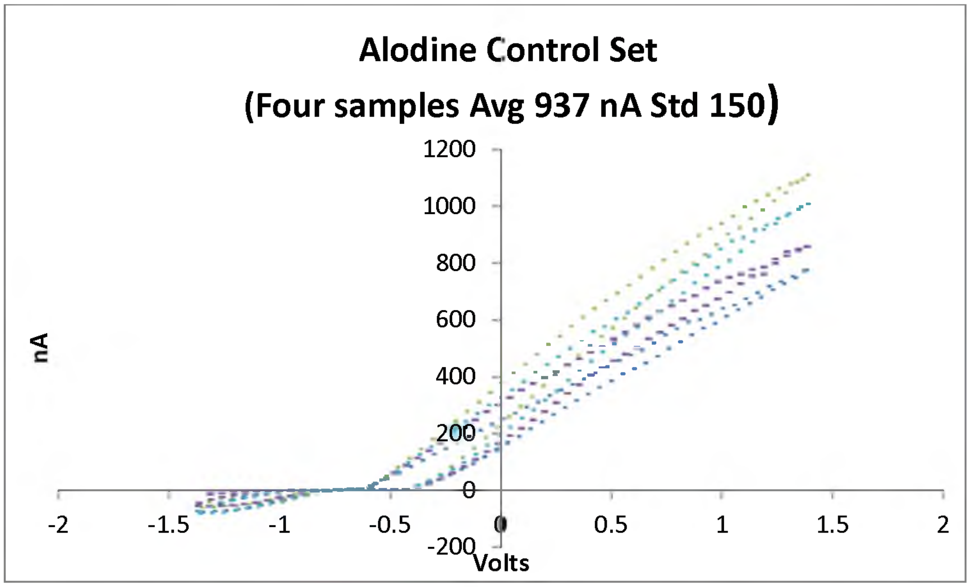


Figure 16
Alodine Control Set

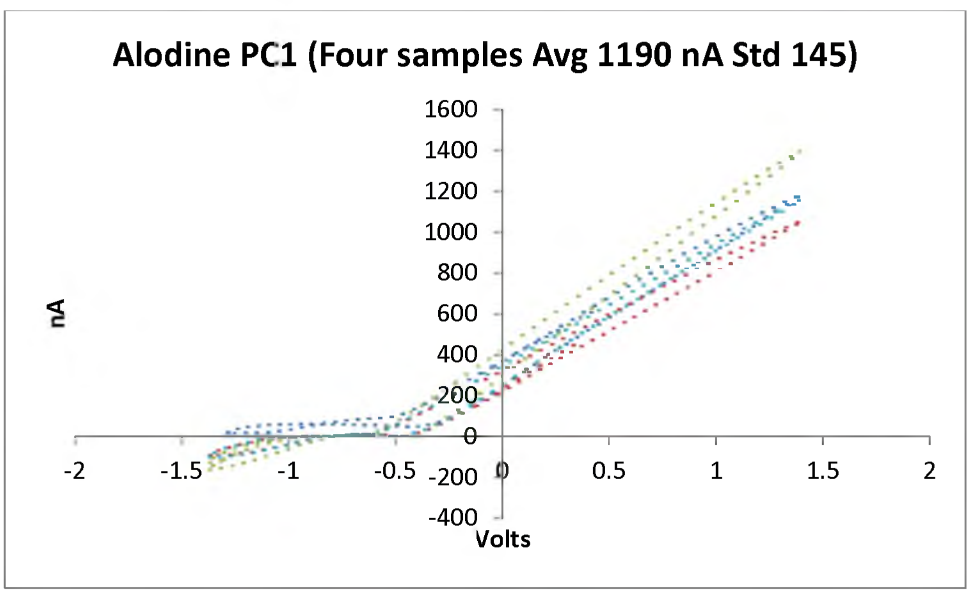


Figure 17
Alodine PC1

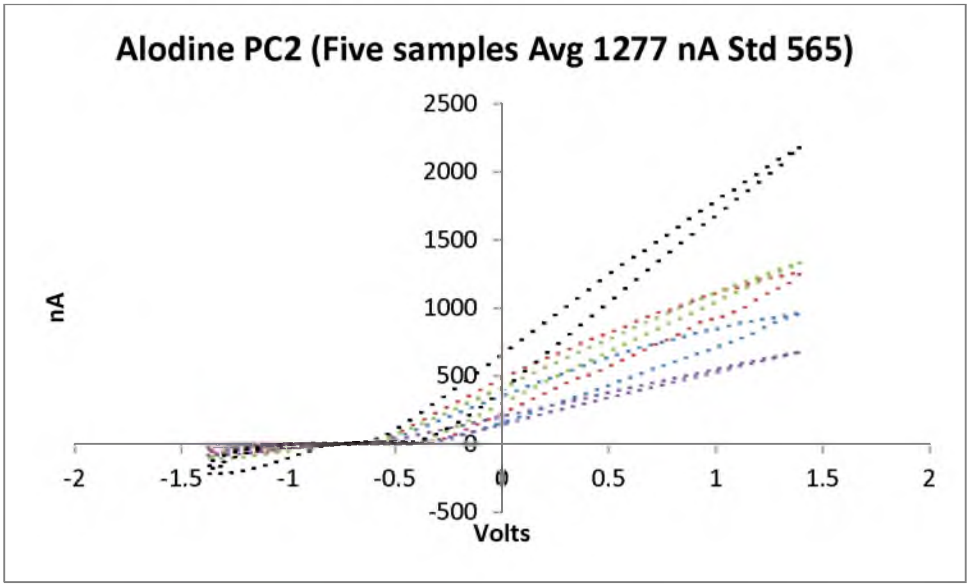


Figure 18
Alodine PC2

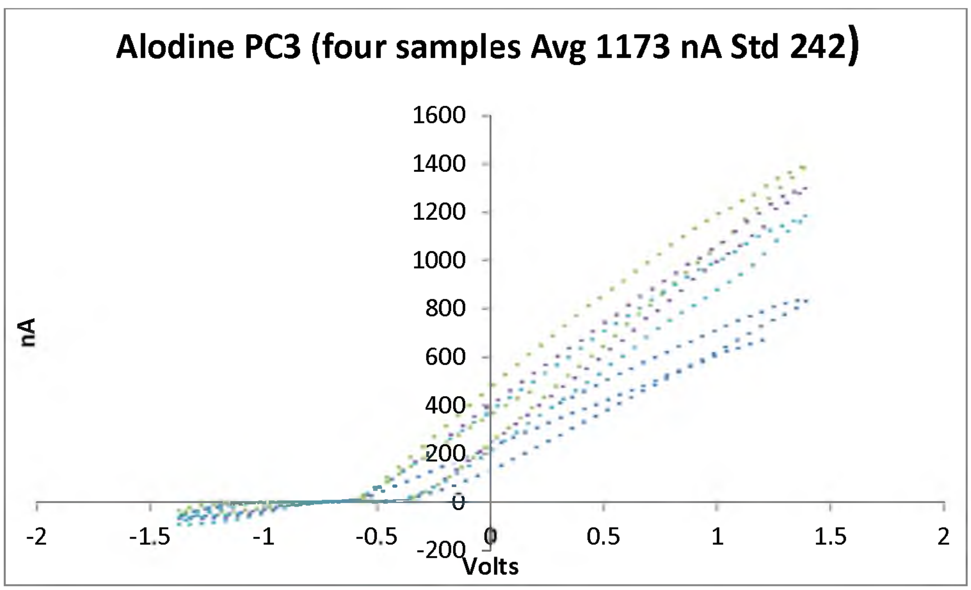


Figure 19
Alodine PC3

E.1.2 Natural Oxide

Data for the Natural Oxide test sets are depicted in Figures 20-23.

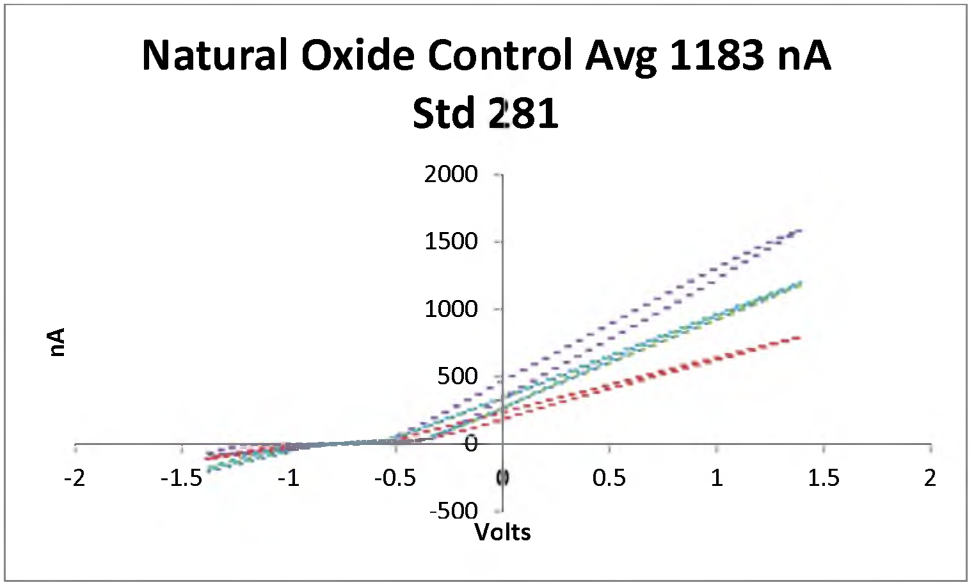


Figure 20
Natural Oxide Control

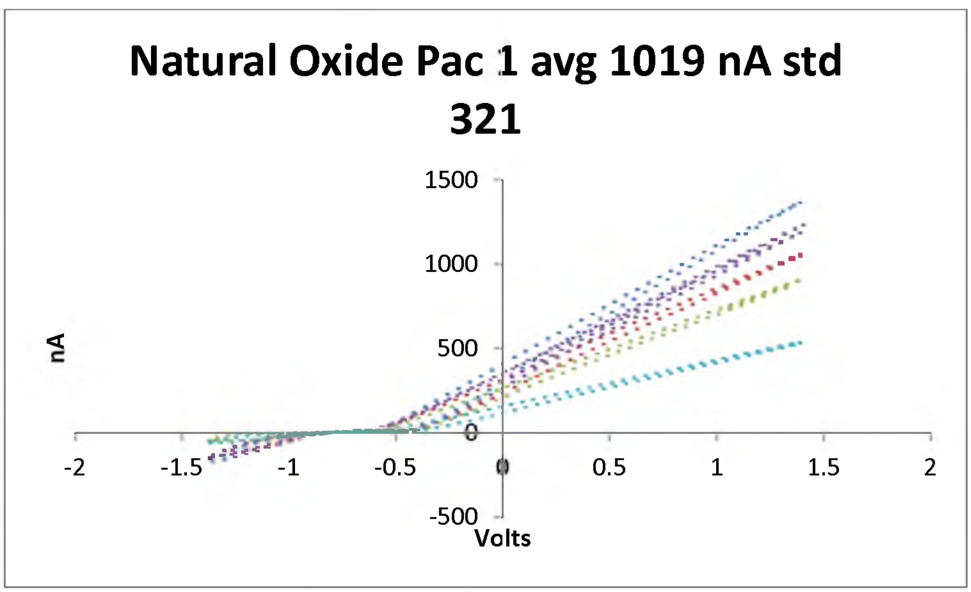


Figure 21
Natural Oxide Pac 1

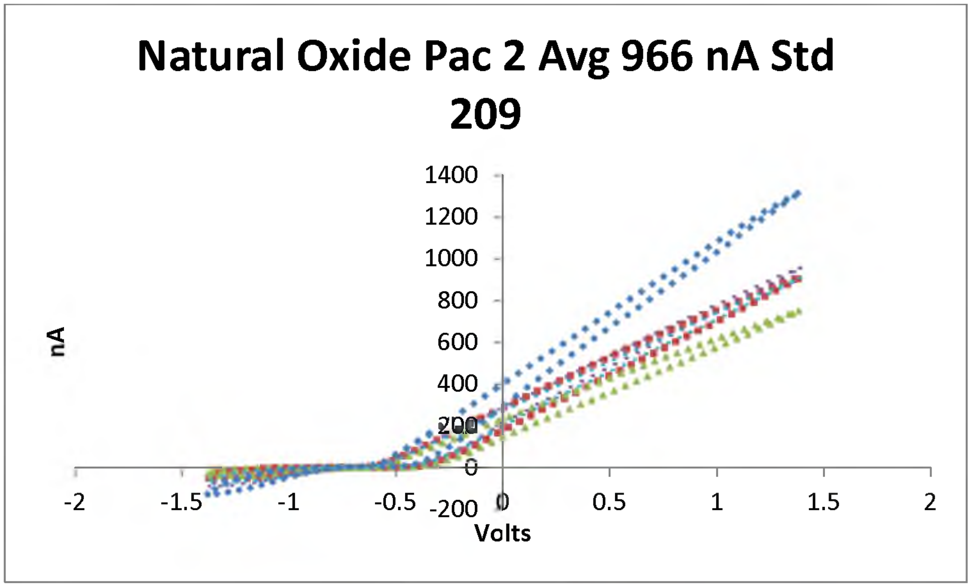


Figure 22
Natural Oxide Pac 2

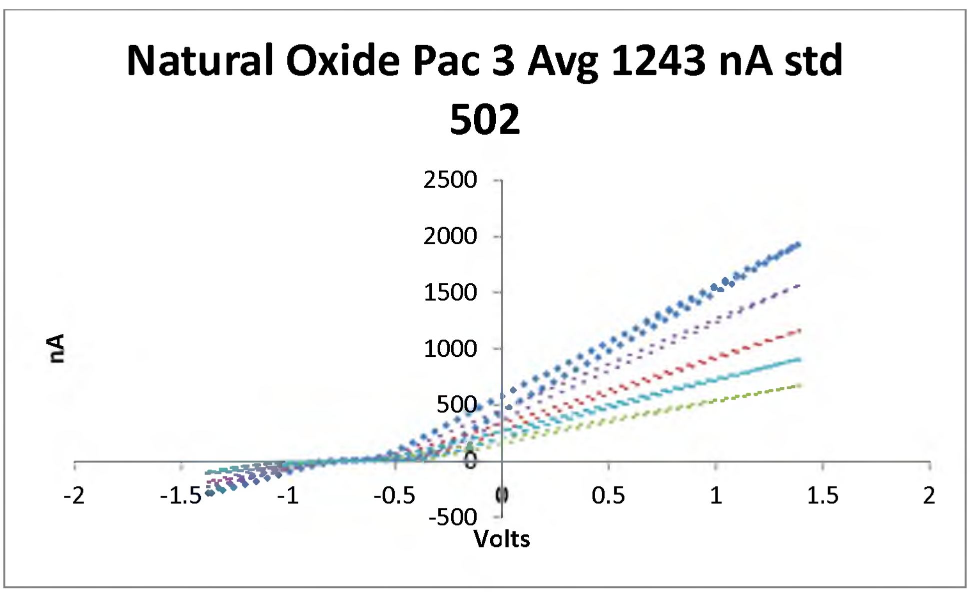


Figure 23
Natural Oxide Pac 3

E.1.3 Type II Anodize

Data for the Type II test sets are depicted in Figures 24-27.

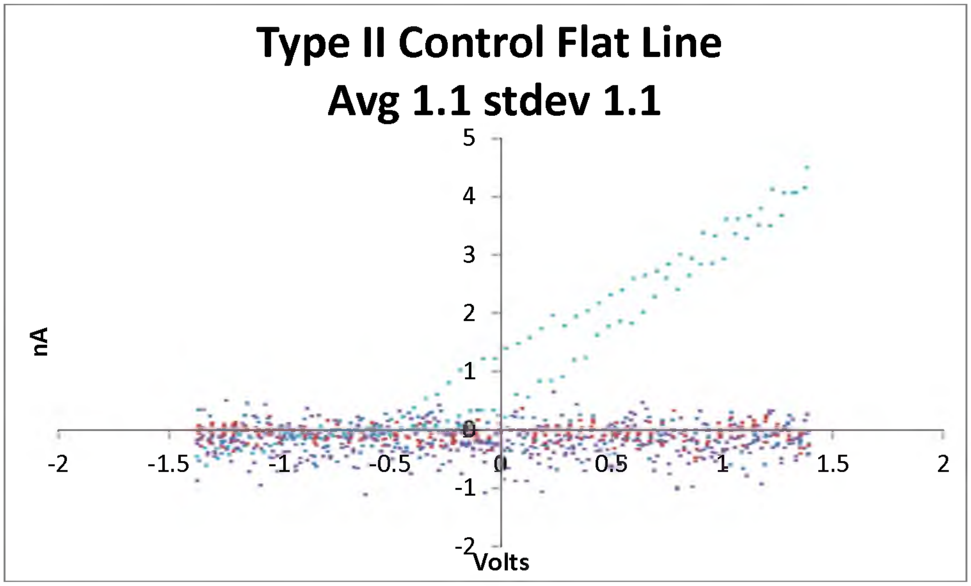


Figure 24
Type II Control

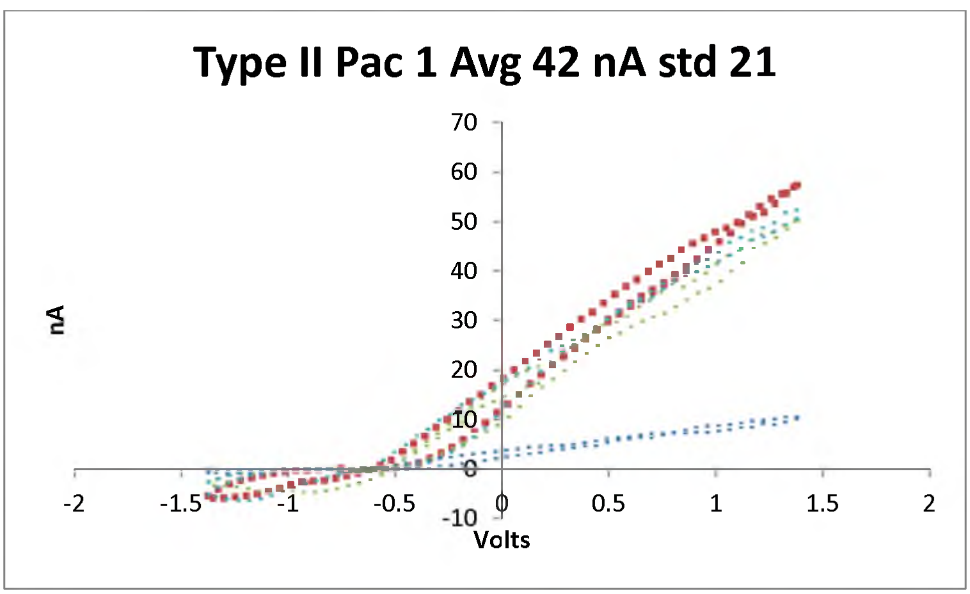


Figure 25
Type II Pac 1

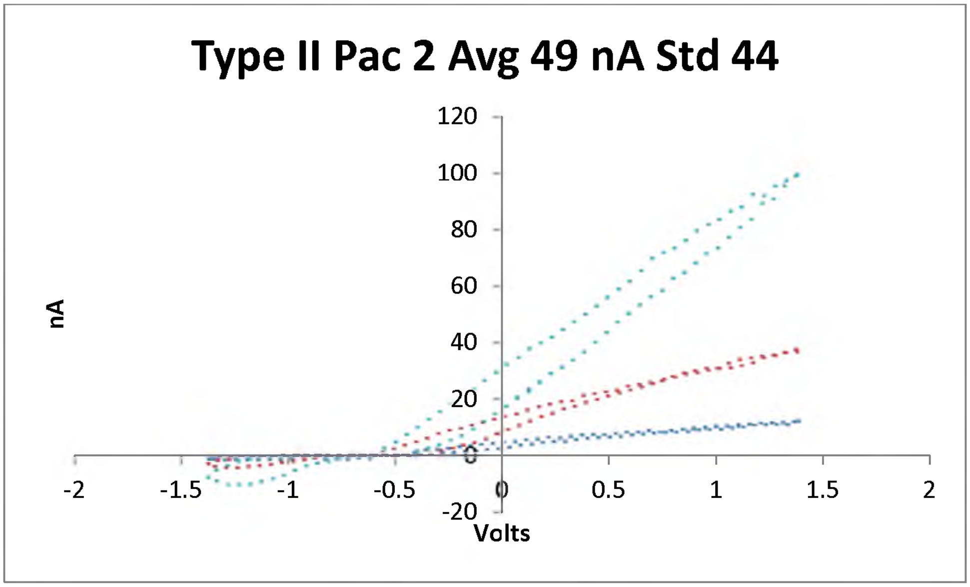


Figure 26
Type II Pac 2

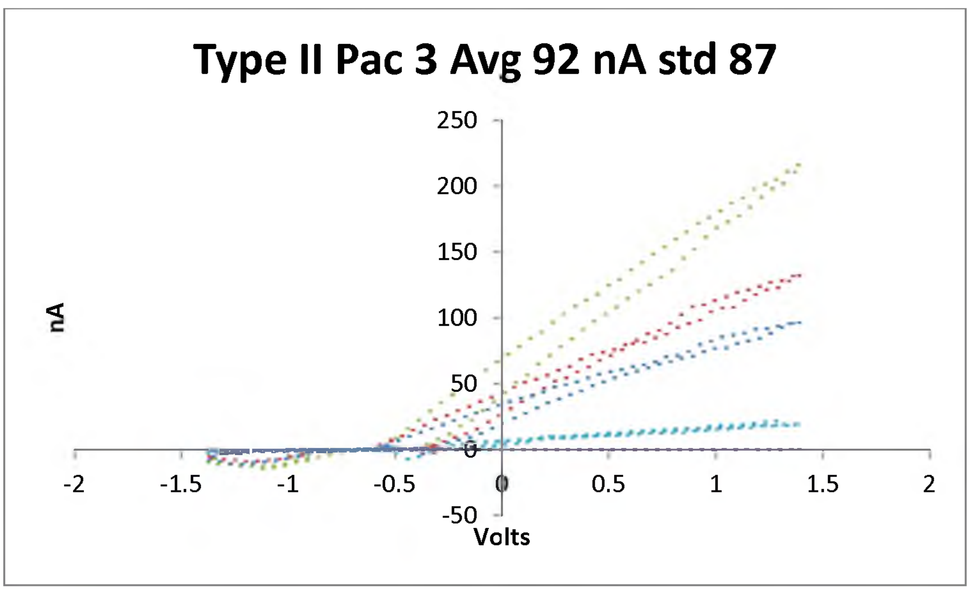


Figure 27
Type II Pac 3

E.1.4 Type III Anodize

Data for the Type III test sets are depicted in Figures 28-31.

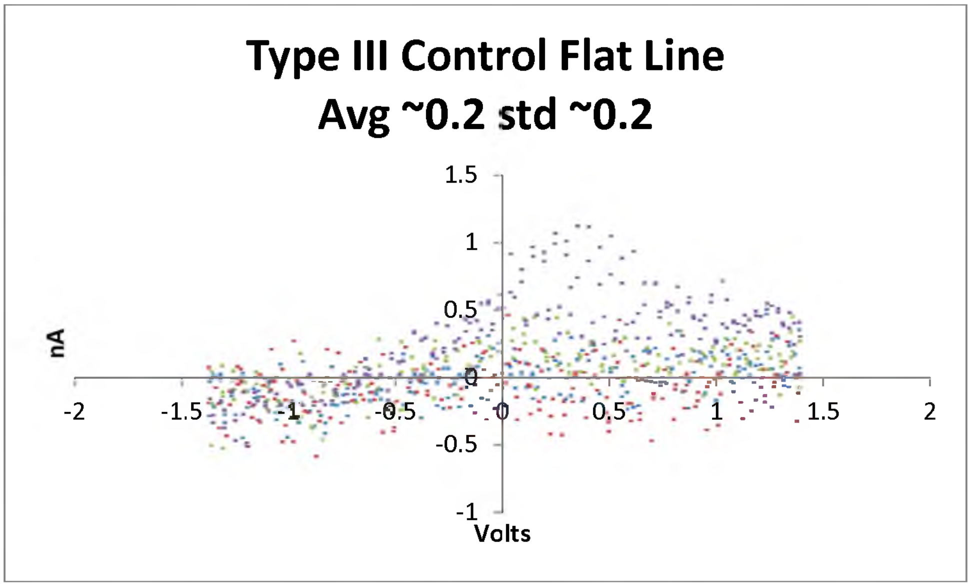


Figure 28
Type III Control

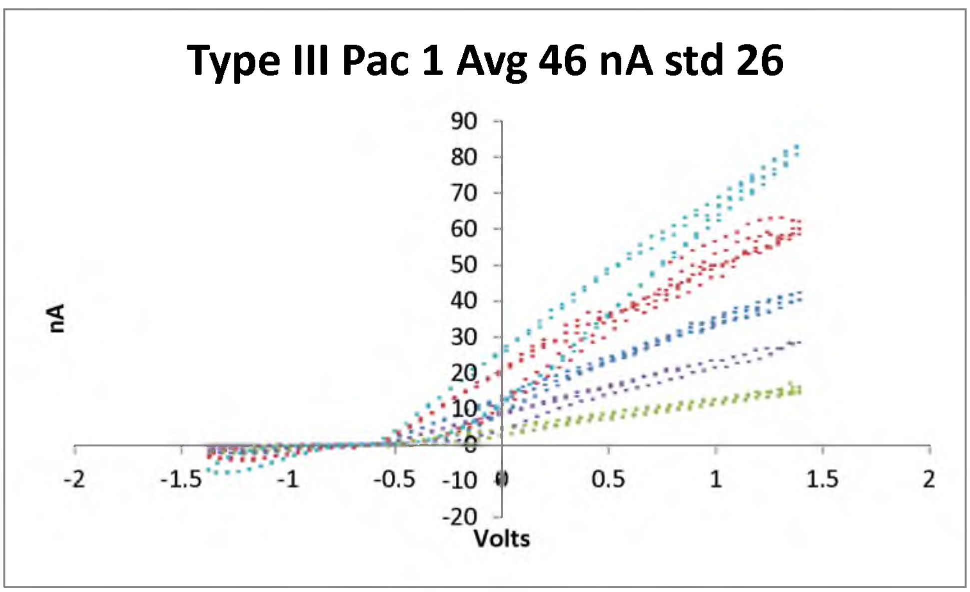


Figure 29
Type III Pac 1

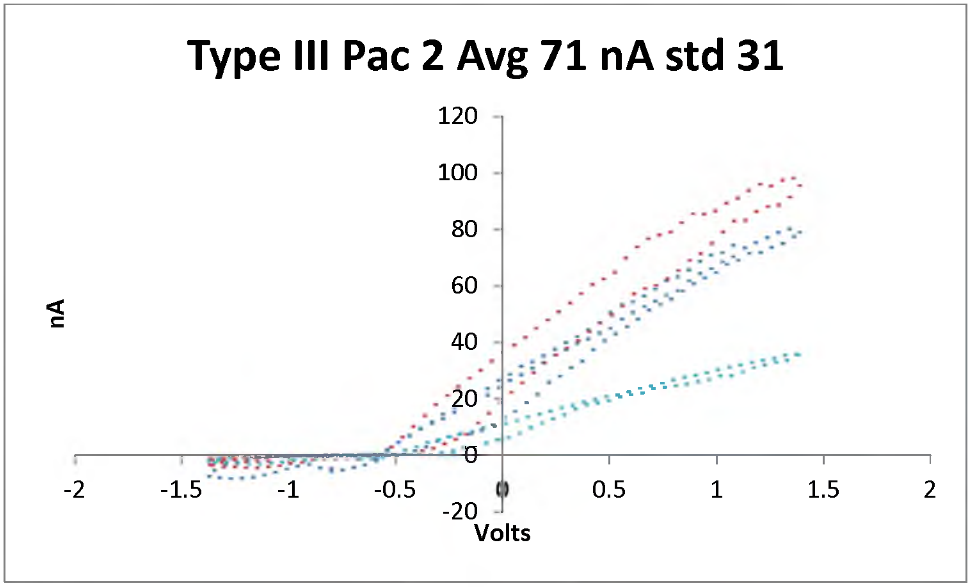


Figure 30
Type III Pac 2

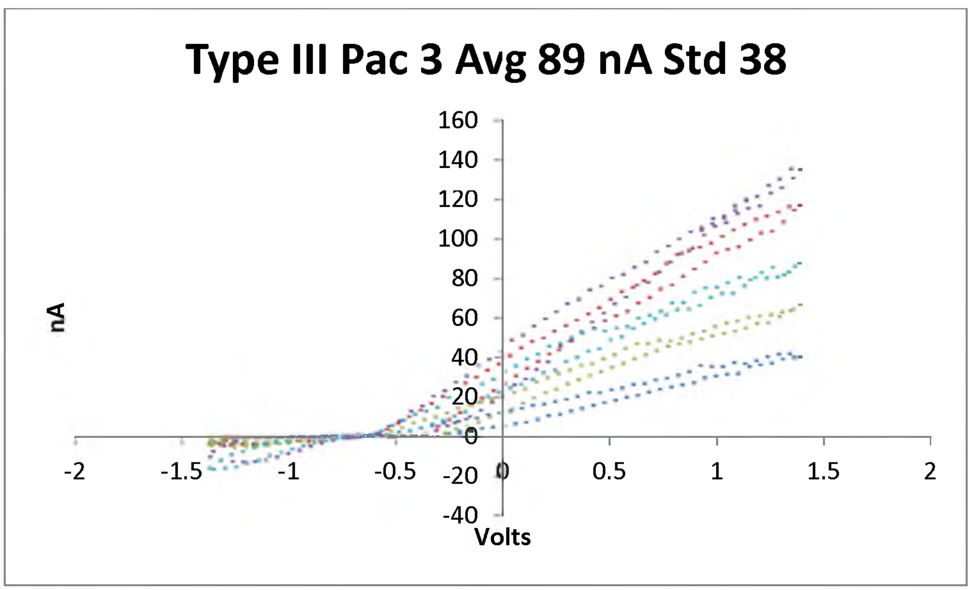


Figure 31
Type III Pac 3

E.1.5 Dissolution Rates For Passive Current Density (PCD)

E.1.5.1 Dissolution Data

	Pac 1	uncertainty	Pac 2	uncertainty	Pac 3	uncertainty	Control	uncertainty
Natural Oxide	1.76 E-10	0.5e-10	1.67 E-10	0.4e-10	2.15 E-10	0.8e-10	2.04E-10	0.5e-10
Alodine	2.05 E-10	0.3e-10	2.21 E-10	0.9e-10	2.03 E-10	0.4e-10	1.62E-10	0.3e-10
Anodize Type II	7.30 E-12	4e-12	8.50 E-12	7.6e-12	1.60 E-11	1.5e-11	1.90E-13	1.9e-13
Anodize Type III	7.94 E-12	4.49e-12	1.23 E-11	0.5e-11	1.54 E-11	0.66e-11	3.50E-14	3.5e-14

Table units (moles/cm^2-sec)
For reaction rate of oxide layer dissolution in a 0.21 Molar solution of NaCl

E.1.5.2 Type II/Type III PCD Results

The Passive Current Density data for the Type II and Type III test sets are graphically depicted in Figure 32.

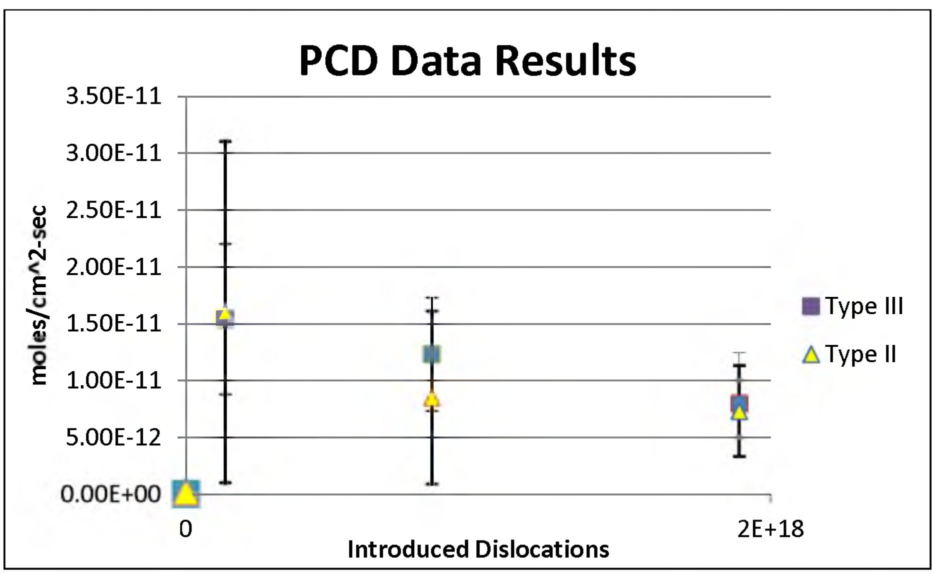


Figure 32
PCD Type II/Type III Data Results

E.1.5.3 PCD Native Oxide/Alodine Results

The PCD data for the Type II and Type III test sets are depicted in Figure 33.

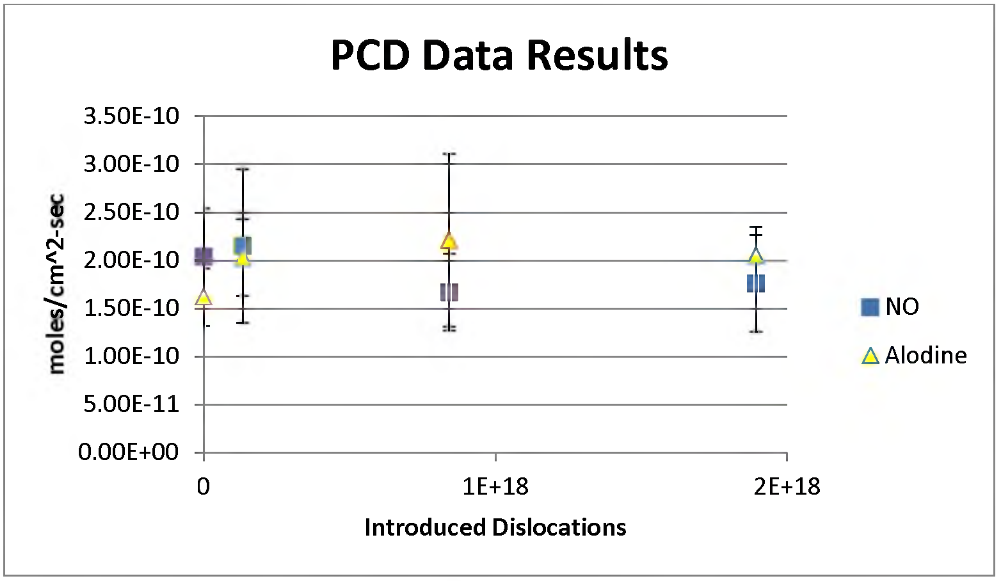


Figure 33
PCD Native Oxide/Alodine Data Results

E.2 Weight Gain Figures

Weight gain data for all of the test sets are depicted in Figures 34-41.

E.2.1 Native Oxide Weight Gain

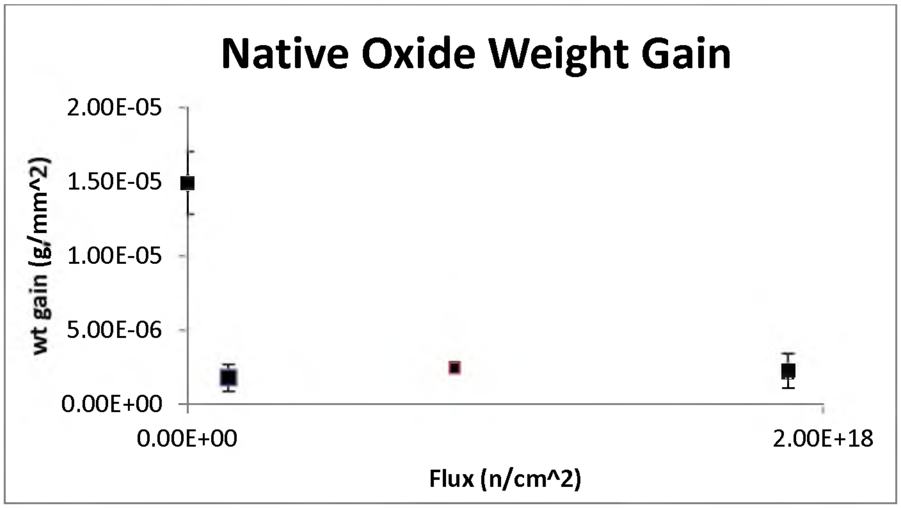


Figure 34
Native Oxide Weight Gain

E.2.2 Alodine Weight Gain

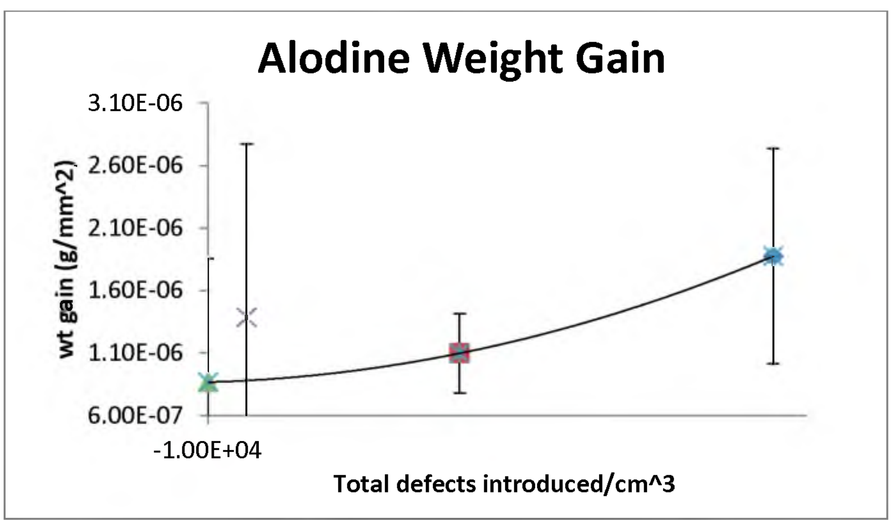


Figure 35
Alodine Weight Gain

E.2.3 Type II Weight Gain

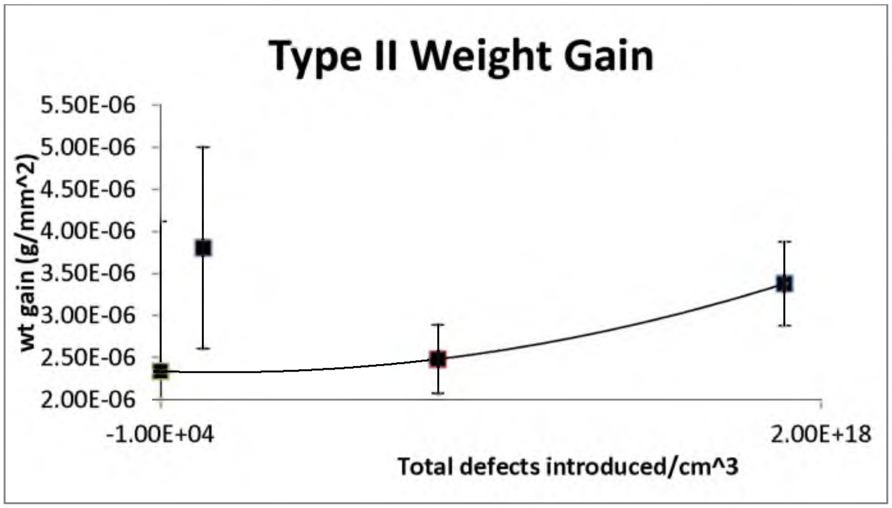


Figure 36
Type II Weight Gain

E.2.4 Type III Weight Gain

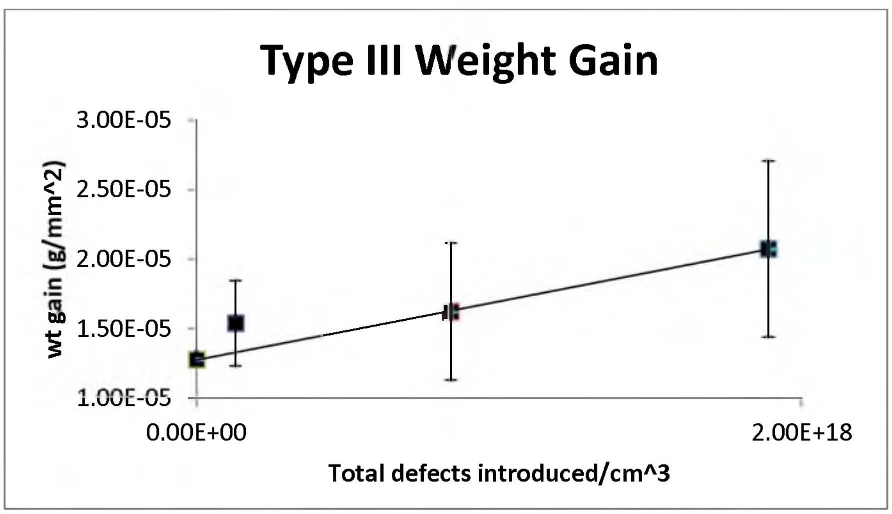


Figure 37
Type II Weight Gain

E.2.5 Radiation Enhanced Flux

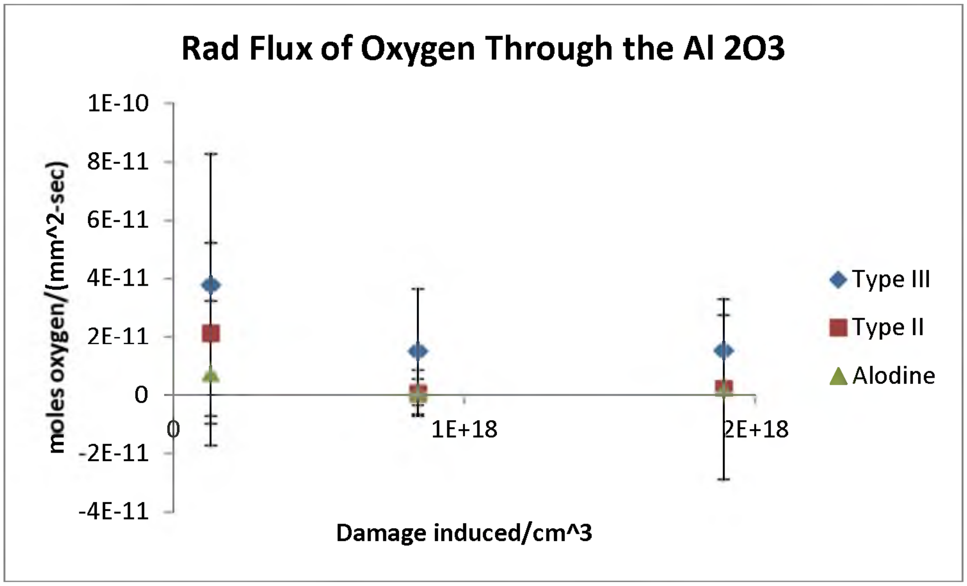


Figure 38
Rad Flux of Oxygen

E.2.6 Type III Diffusion Coefficient

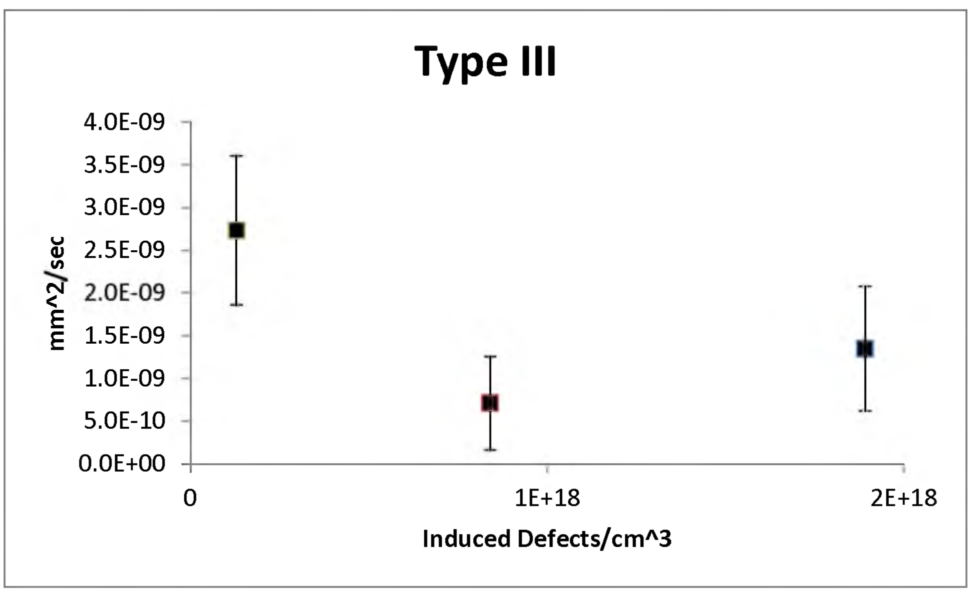


Figure 39
Type III

E.2.7 Type II Diffusion Coefficient

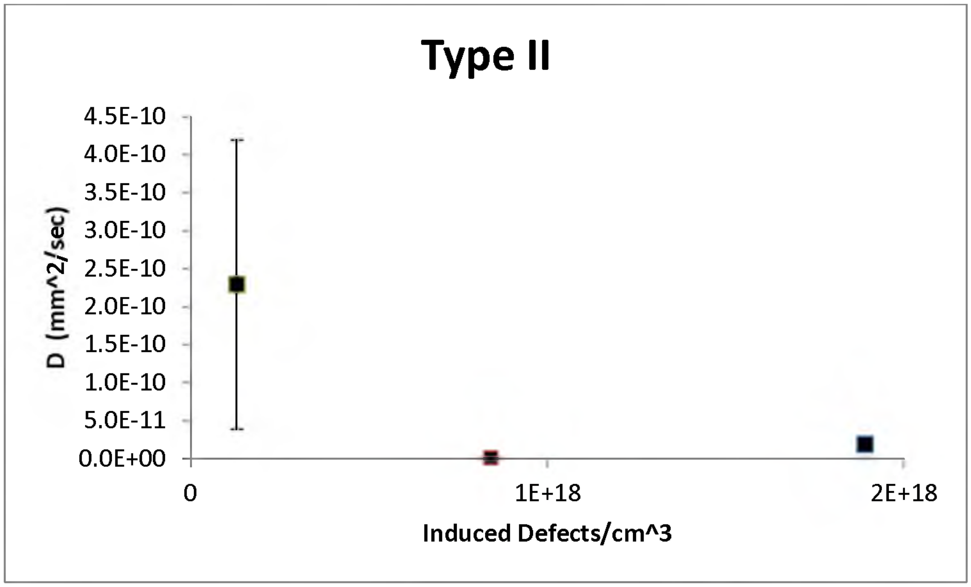


Figure 40
Type II

E.2.8 Alodine Diffusion Coefficient

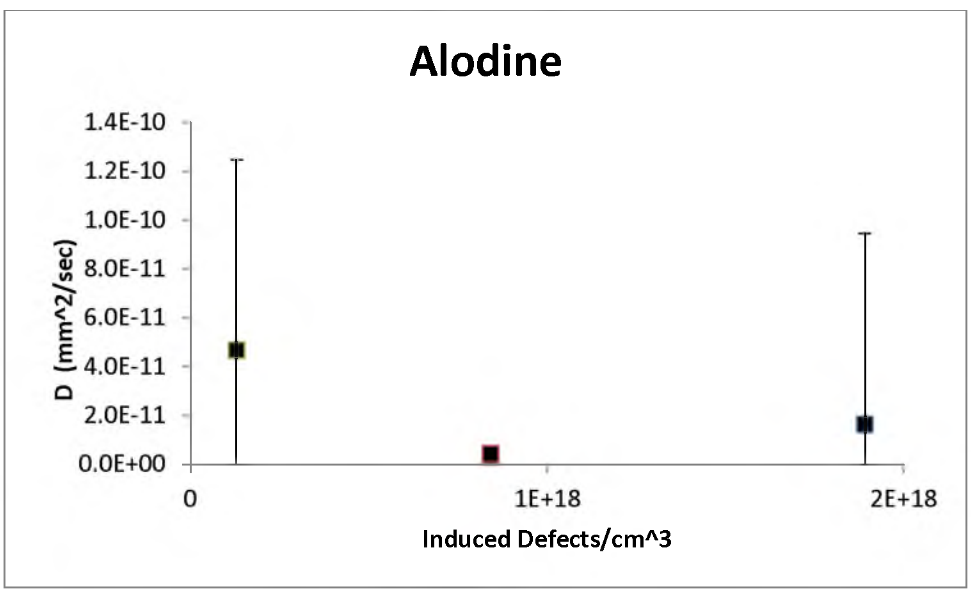


Figure 41
Alodine

E.3 Thermal Conductivity Data Results

	Pac 1	Pac 2	Pac 3
Time to measurement (days)	37	18	11
Total damage retained (defects/m^2)	1.49E+17	1.43E+17	1.29E+17
% reduction thermal conductivity	28	27	22
Average defect retention	1.37E+17		
uncertainty 1 stdev defect retention	1.66E+16	~ 12 %	

E.4 Wire Resistance Figures

Data from the wire resistance tests are depicted in Figures 42-46.

E.4.1 Increased Resistance

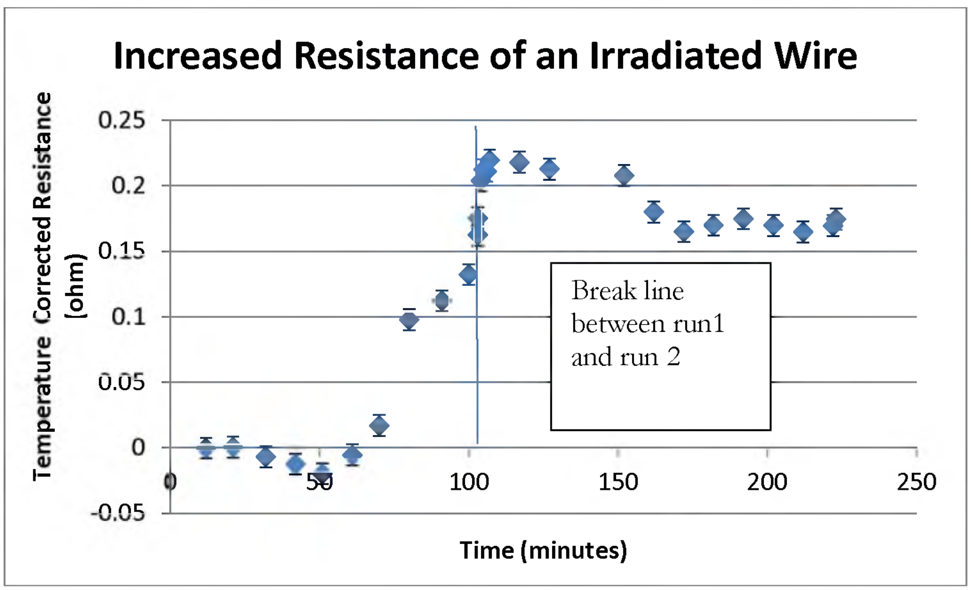


Figure 42
Increased Wire Resistance

E.4.2 Void Recovery

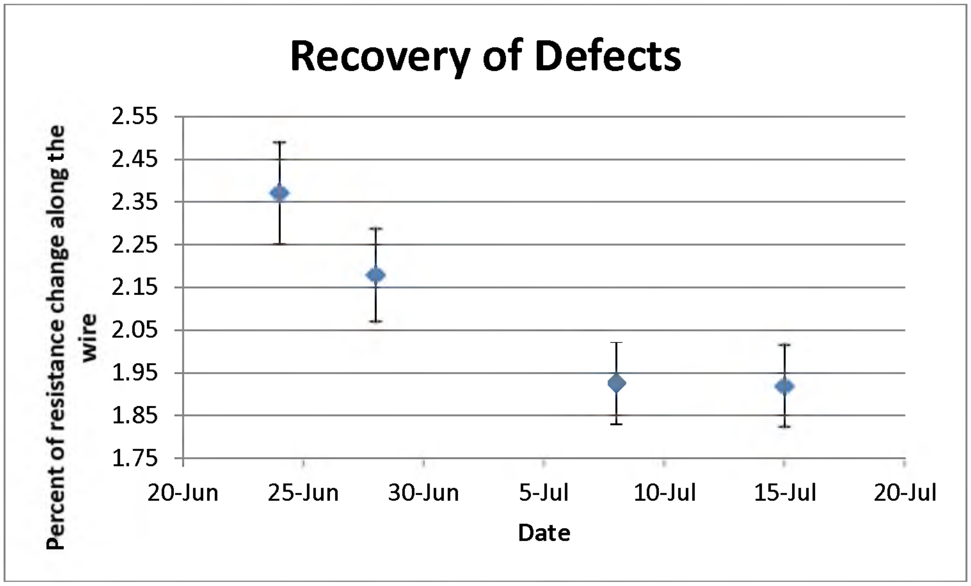


Figure 43
Recovery of Defects

E.4.3 Total Defect Comparison

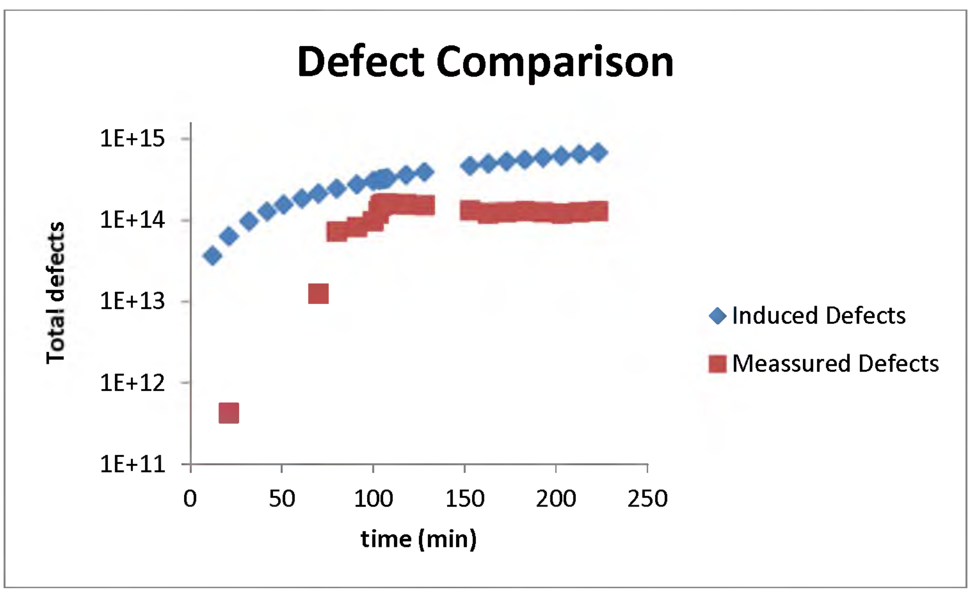


Figure 44
Defect Comparison

E.4.4 Defect Concentration

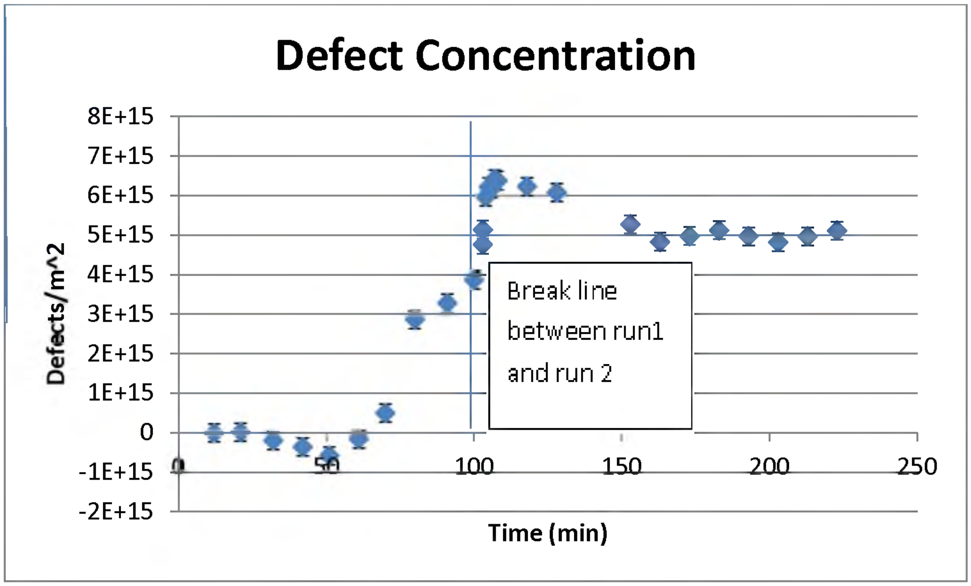


Figure 45
Defect Concentration

E.4.5 Defect Recovery

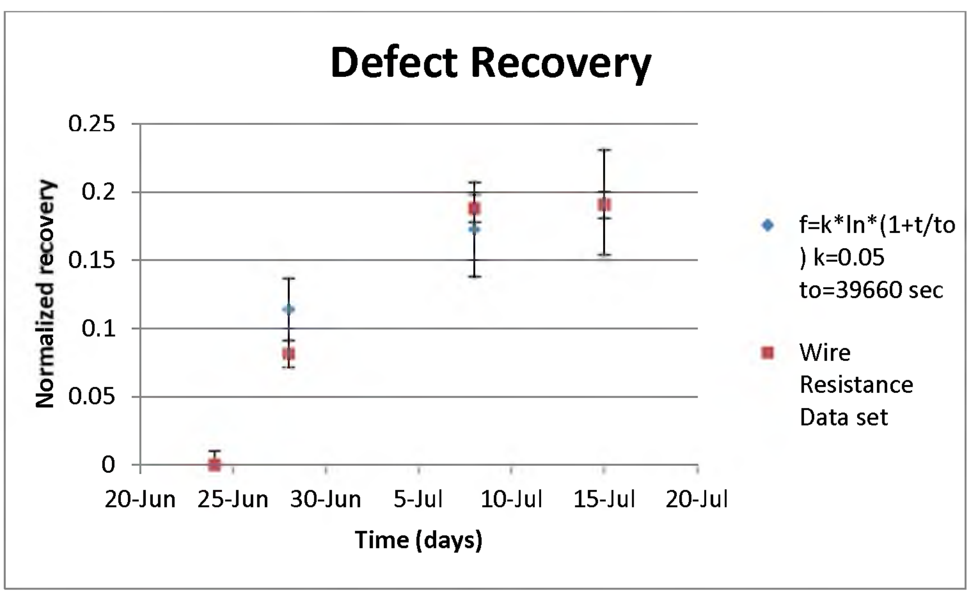


Figure 46
Defect Recovery

E.5 Flux Map

The flux map data are graphically depicted in Figure 47.

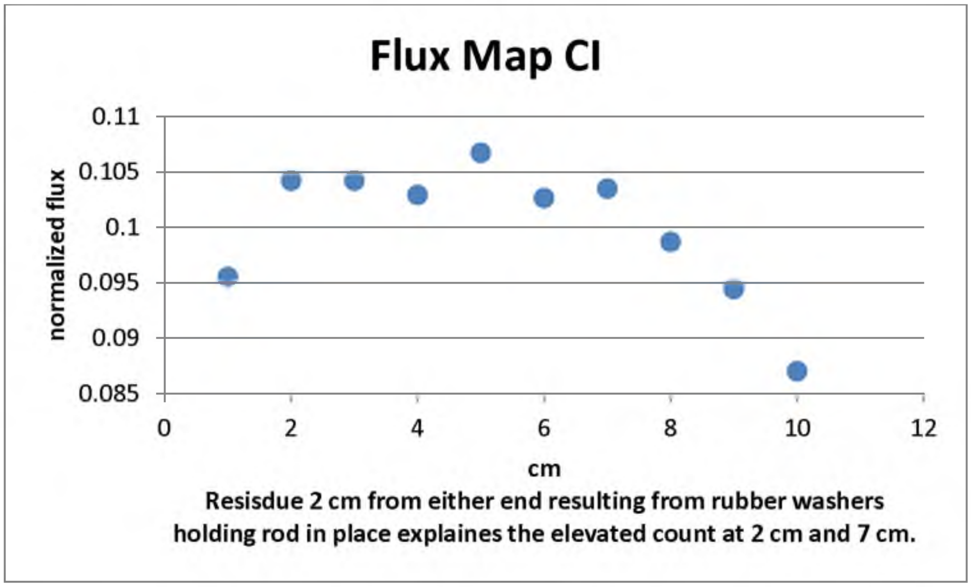


Figure 47
Flux Map CI

E.6 Neutron Cross Sections

The cross sectional data in section E.6 was used to evaluate the damage rate in the Aluminum alloy 2024 (*40*). The data is available online from ENDFPLOT which is a CGI program to generate graphs from the MCNP5 library data and/or Point wise ENDF library. Cross sections are depicted in Figures 48-51.

E.6.1 Aluminum

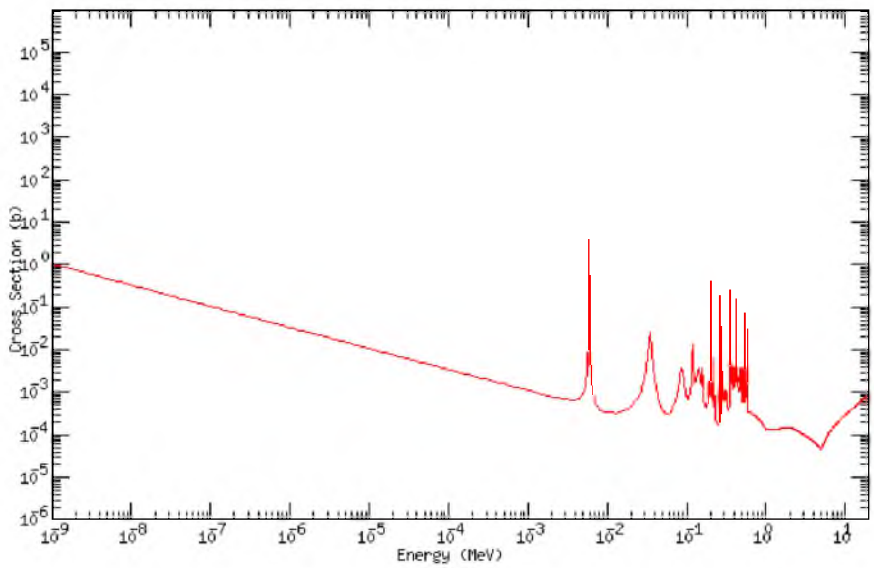


Figure 48
Aluminum

E.6.2 Oxygen

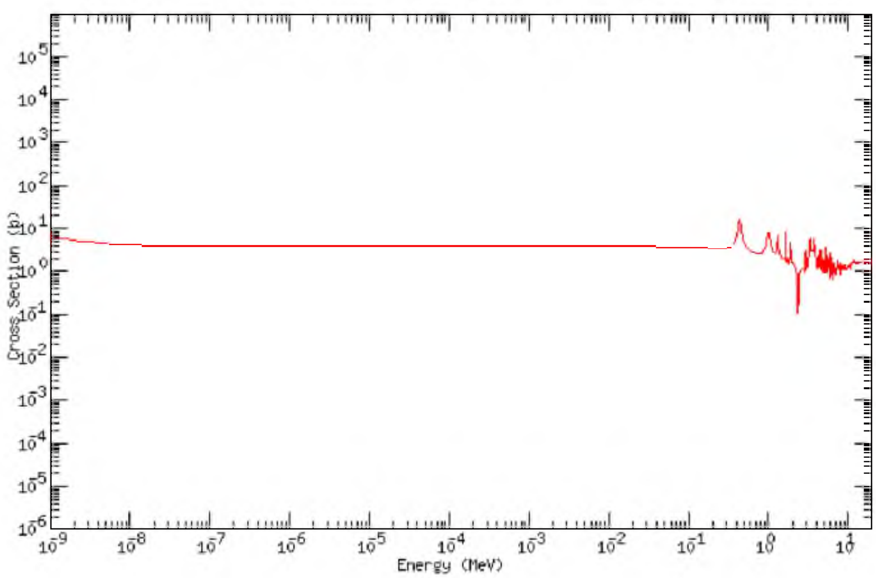


Figure 49
Oxygen

E.6.3 Copper

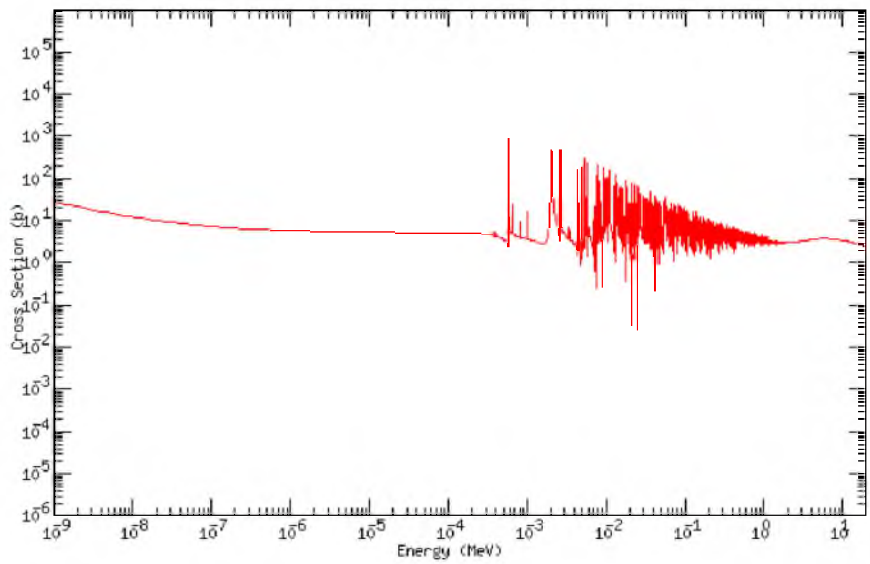


Figure 50
Copper

E.6.4 Magnesium

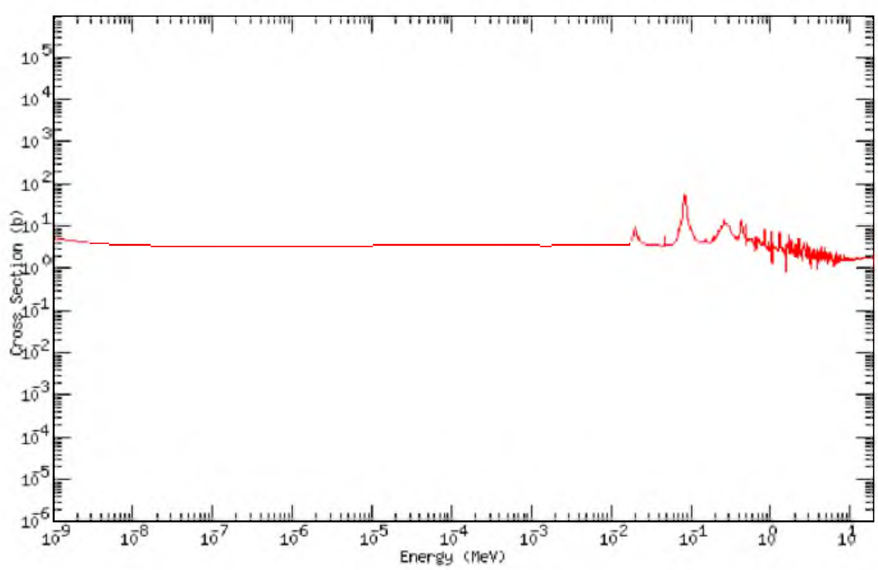


Figure 51
Magnesium

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2- Seagondollar, L. W.; Barschallk, H.H. *Total Cross Section of Aluminum for Fast Neutrons* The American Physical Society. 1947

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